1983

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Jackson, Terry D.

Monterey, California. Naval Postgraduate School

http://hdl.handle.net/10945/19709

NAVAL POSTGRADUATE SCHOOL
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THESIS

COST-EFFECTIVENESS OF MANAGEMENT ACTIVITIES RELATED
TO THE INTERACTION BETWEEN THE CALIFORNIA
SEA LION
AND THE SOUTHERN CALIFORNIA SHARK GILL-NET FISHERY

by

Terry Doyle Jackson

March 1983

Thesis Advisors: D. C. Boger
R. G. Nickerson

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Cost-Effectiveness of Management Activites Related to the Interaction Between the California Sea Lion and the Southern California Shark Gill-Net Fishery		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis March 1983
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Terry Doyle Jackson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93940		12. REPORT DATE March 1983
		13. NUMBER OF PAGES 88
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Marine Mammals	Cost-Effectiveness
Sea Lions	Management
Pinnipeds	Shark Gill-Net Fishery

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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Cost-Effectiveness of Management Activities Related to the Interaction Between the California Sea Lion and the Southern California Shark Gill-Net Fishery

by

Terry D. Jackson
Lieutenant, NOAA Corps
B.A., University of California, Santa Barbara, 1973

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
March, 1983

ABSTRACT

The California Department of Fish and Game is presently considering a request to the Secretary of Commerce to regain management authority of the California sea lion because of mortalities and economic loss resulting from interactions with coastal fishermen. Before the request can be submitted various costs concerning State managment have to be studied. This thesis addresses the cost and effectiveness of five activities relating to the interaction between the shark drift-gill-net fishery in Southern California and sea lions. The activities discussed are: assessing population levels, assessing incidental take, limiting the use of gill-nets by area and time of year, estimating the loss of fish and gear due to depredation, and estimating the value of an acoustical playback device. Where applicable, the cost and effectiveness of different alternatives within an activity are compared to provide criteria for evaluation. Each activity is examined from an economic perspective of what it might cost the State or gill-net-fishery if the activity were incorporated into an overall management plan of California sea lions.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

The California Department of Fish and Game (CDF & G) is presently considering a request to the U.S. Secretary of Commerce to regain management authority of several species of marine mammals that occur along the coast of California. Of particular interest to the State is the California sea lion (Zalophus californianus) because of its high mortality rate resulting from fishery conflicts and the fact that it is responsible for most of the economic loss that the California fishermen experience as a result of marine mammal interactions. This request for management, however, can only be made after all the economic and social costs concerning State management have been studied. Such an analysis for all the fisheries in which sea lions interact is beyond the scope of this thesis. The thesis will only address the cost and effectiveness of different activities that the State could implement to manage interactions between California sea lions and the shark drift-gill-net fishery operating in Southern California.

The thesis is presented in four major chapters. Chapter Two provides background information on the Marine Mammal Protection Act, the Coastal Marine Mammal Program, and the shark drift-gill-net fishery. It also describes the problems connected with the interaction and presents reasons why the State is interested in regaining management authority. Chapter Three looks at the cost and effectiveness associated with five management activities. Analyses of the first two activities, assessing population levels and incidental take, compare the costs of different alternatives within each activity to their effectiveness in achieving the objective of the activity. The last three activities, limiting the

use of gill nets by area and time of year, estimating the economic loss to fishermen due to depredation, and estimating the value of the acoustical playback unit, are combined in an effort to assess the economical impact of sea lion/fishery conflicts on the State and the shark gill-net industry. Chapter Four is a sensitivity analysis of the assumptions made in estimating costs. The final chapter, conclusions and recommendations, evaluates the study and makes recommendations.

The purpose of the thesis is to estimate costs associated with each of these activities in an effort to provide cost criteria for decision makers designing an overall management plan for the California sea lion. It is hoped that the thesis will provide useful information for those individuals so that a cost-effective management plan can be developed and included in the return-of-management package submitted to the Department of Commerce.

II. BACKGROUND

A. MARINE MAMMAL PROTECTION ACT

Prior to the passage of the Marine Mammal Protection Act (MMPA) marine mammal protection and conservation was the responsibility of coastal states, such as Alaska, California, etc., and international authorities, such as the International Whaling Commission (IWC), and the International Commission of the North Atlantic Fisheries (ICNAF). Management by some of these authorities was ineffective and, in the late 1960's, led to a growing anxiety by the American public that certain species and populations of marine mammals were being depleted or even becoming extinct as a result of human activity. Of particular interest was the lack of control by the IWC in controlling commercial whaling, the incidental take of porpoise by the U.S. tuna purse seine fishery, and the clubbing of baby harp seals in the North Atlantic. A direct result of this concern was the passage of the MMPA (Public Law 92-522) on October 21, 1972. The Act took a strong preservationistic position regarding marine mammals.

The primary objective of the MMPA is to maintain the health and stability of the marine ecosystem and, whenever consistent with the primary objective, to obtain and maintain optimal sustainable populations of marine mammals (MMPA Amended, 1981). Optimium sustainable population (OSP) is defined by the Act as:

> "The number of animals that will result in the maximium productivity of the population or species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element" (MMPA, Section 3 (7), 1981).

The Act also establishes a moratorium on the taking of marine mammals in U.S. waters and/or the importation of marine mammals and marine mammal products into the U.S. Exemptions are granted for the taking of marine mammals by certain natives for subsistence, handicraft and clothing. "Take" is defined in the Act to mean:

> "harassing, hunting, capturing, or killing or attempting to harass, hunt, capture or kill any marine mammal" (MMPA, Section 3 (12), 1981).

In addition to exemptions, the Act also provides for a waiver of the moratorium in certain situations, the return of management authority to individual states, and the issuance of permits to take marine mammals incidental to fishing operations, for scientific research, and for public display.

The MMPA also created the Marine Mammal Commission (MMC), a group of three individuals appointed by the President and knowledgable in marine ecology and resource management, and a nine member Committee of Scientific Advisors, charged with overviewing all U.S. activities related to the protection and conservation of marine mammals. The MMC is responsible for monitoring activities regarding marine mammals and insuring that the objectives of the Act are carried out.

Another feature of MMPA is that it directs the Secretaries of Commerce and Interior, through the Secretary of State, to initiate negotiations for international agreement which follow the principles of the Act. The Department of State is responsible for treaties concerning the protection and conservation of marine mammals, commercial fishing operations where marine mammals are taken incidental to the operation, and the protection of specific land and oceanic regions which are significant or critical habitats of marine mammals (Section 108).

In 1976, the MMPA was amended by Section 404 of the Fisheries Conservation and Management Act (Public Law 94-265, 13 April) to include within the phrase "waters under the jurisdiction of the United States" the waters of the U.S. Fisheries Conservation Zone (FCZ) established by the Fisheries Conservation and Management Act (FCMA). This means that the MMPA now applies to a zone contiguous with the U.S. territorial sea and extending 200 nautical miles offshore from the coast (the same baseline from which the territorial sea is measured) of the U.S. and its territories. Within this zone the U.S. excercises exclusive fisheries management authority (including marine mammals) over all fish resources except highly migratory species, such as tuna. Under the Act, the U.S. regulates the activities of domestic and foreign fishing vessels, the resources of the continental shelf, and the fishing activity of U.S. citizens outside the FCZ.

The MMPA was again amended on October 9, 1981 (Public Law No 97-58). Major aspects of the revised Act are:

1) Return of marine mammal management to the states,
2) Small takes of marine mammals,
3) Beached and stranded animals,
4) Marking and tagging,
5) Definitional changes,
6) Restatement of immediate goal test for tunamen, and
7) Reauthorization.

The first item listed above, return of marine mammal management to the state (Section 109), provides a new approach of returning management authority to the states.

The new approach, designed to alleviate some of the problems associated with the pre-amendment process, contains four distinct phases for returning management authority. The first phase is a state's request for the return of management, submitted to the Secretary of the appropriate

federal agency. This request is essentially a proposal of what the state's marine mammal program will be. Section 109 (b) of the amended Act specifies the minimum requirements for developing an acceptable request. Phase two requires that the state determine the status of the population with respect to OSP for the marine mammal species it desires to manage. Until the OSP for this species has been determined, the state is prohibited from allowing any taking of marine mammals from that stock. Phase three involves the expansion of the state's management authority which takes effect after the state's determinations are final and implemented under state law and after a cooperative agreement between the state and necessary federal agencies has been reached. At that time, the legal responsibility for management passes from the federal government to the state. The final phase involves potential federal revocation of the management authority previously returned to a state or a state's voluntary return of the management back to the federal government. Both aspects are governed by Section 109 (e) of the amended Act.

The Marine Mammal Protection Act and its amendments provide management guidelines based on ecosystem principles, that animals must be managed for their benefit and not for the benefit of commercial exploitation. This new approach, far different from the fisheries tradition of managing fish stocks using maximum harvests and average stock sizes, is now the responsibility of the federal government and exercised through various coastal marine mammal research programs. The objective, responsibilities and duties of the federal Coastal Marine Mammal Program with jurisdiction over the California coastal waters is discussed in the following section.

E. COASTAL MARINE MAMMAL PROGRAM

The MMPA and the Endangered Species Act (Public Law 93-205, 28 December 1973) mandate that the National Marine Fisheries Service (NMFS), U.S. Department of Commerce, is responsible for managing populations of pinnipeds (seals and sea lions), except walrus, and cetaceans (whales and dolphins) that occur within 200 miles of territorial claims of the United States. These two acts further put a moratorium on the taking of any marine mammals by U.S. citizens unless specifically exempted within the MMPA. Permits to take for public display, incidental to a fishery, or for research may be issued by the NMFS, but only if a determination concerning the present status of a particular marine mammal population has been made. Therefore, the primary objective of the Coastal Marine Mammal Program at the Southwest Fisheries Center (SWFC), NMFS, is to conduct research that will enable assessments to be made for stocks of marine mammals that occur off the California coast.

The status of a marine mammal population has been interpreted by the courts to refer to the relationship between the current population size, the maximum net productivity level (MNPL), and the carrying capacity of the environment or maximium population level (K). Basically, if a population is above MNPL, it is at OSP. If it is below MNPL, it should be considered depleted. Unfortunately, estimating these three population levels is a complicated task including various problems, such as uncertainty concerning all the variables. Considering the many problems associated with an assessment, determination guidelines in the assessment procedure were developed that deal with OSP. According to the guidelines, a marine mammal population is within OSP when:

1. The increase in population size is slowing and the historical range is occupied, or
2. Population size is not undergoing a persistent decline and the historical range is occupied.

A population is below OSP when:

1. A decline in population size persists for five or more years, or
2. An increase in population size is geometric, or
3. A population occupies less than 60 percent of historical range.

These criteria allow for a determination of status without direct estimates of K and MNPL. The needs of the procedure are centered around detecting changes in the trend of population growth and on two assumptions. First, this approach assumes that a population is larger than the MNPL population when the growth rate of the population starts to slow down. It further assumes that when a population is persistently declining, whether near K or not, it is not at an optimum level. Using these guidelines and criteria the basic informational needs required to assess a population level are:

1) The population growth rate over time,
2) The current distribution of animals,
3) The historical distribution of animals, and
4) The number of discrete stocks within the species.

These guidelines, assessment criteria, and information needs are offered to illustrate some of the many elements that must be considered in developing different management plans for each species of marine mammal. This new approach of assessing a population level is the framework used in estimating costs to assess the population levels of California sea lions, one of the management activities addressed herein. Because of this framework other procedures to determine OSP, that require more complicated and harder-to-acquire information, are not discussed.

C. DESCRIPTION OF THE PROBLEM

The coastal waters of California support a variety of fishing operations including: commercial trolling for salmon, gill-netting for shark and other pelagic fish, round haul net fishing for anchovy/mackeral, squid and herring, trawling for ground fish, and pole and line fishing from sportboats. During the normal operation of these fisheries conflicts occur between marine mammals and the fishery resulting in economic loss to the fishermen and marine mammal mortalities. The MMPA and other legislation mandate the protection of marine mammals and require the issuance of permits for the taking of mammals incidental to normal fishing operations. These permits, issued by the U.S. Secretary of Commerce, may not be distributed unless the mortality levels are monitored and the population levels are known to be at an optimium level. Below that level they are classified as depleted and take cannot be authorized.

Marine mammal/fishery conflicts generally involve two types of interaction: situations of direct competition for a food source between fishermen and mammals, and situations where mammals are taken incidentally or accidentally during fishing operations. Direct competition causes economic loss to the fishing fleet due to depredation by marine mammals. Miller et al., (1982) estimated an annual fish loss of $503,760 and a gear loss of $94,930 as a result of this competition (Table I). The second situation, where mammals are incidentally caught during fishing operations, is the major cause of mortality along the California coast. Marine mammal mortality caused by fishing activity per year for all fisheries was estimated in 1980 to be approximately 1800 animals (DeMaster et al., 1983). About 90 percent of these deaths were California sea lions with over 1500 estimated taken by all fisheries (Table II). The shark drift-gill-net

fishery was the cause of approximatly 60 percent of those mortalities with over 952 (range 678-1277) of the estimated 1560 (range 1285-1834) sea lion mortalities occuring in the shark gill-net fishery (DeMaster *et al.*, 1983). According to the NMFS, the most pressing problem facing marine mammal management in California is the incidental take of sea lions in the shark gill-net fishery.

TABLE I

Annual Loss of Fish and Gear Due to Depredation

	Fish Loss	Gear Loss	Total
Salmon Fisheries			
Commercial Troll	$274,000	$12,200	$286,220
Partyboat	6,000	360	6,360
Skiff	2,300	0	2,300
Klamath River	74,000	10,000	84,000
Total Salmon	$356,300	$22,580	$378,880
Partyboat (Non salmon)	$27,000	$10,730	$37,730
Pacific Herring	$57,100	$4,550	$61,650
Gill Net	$63,360	$57,070	$120,430
Total All Fisheries	$503,760	$94,930	$598,690

Source: Miller *et al*, 'California Marine Mammal Interaction Study, 1979-1981', Abstract p.ii

TABLE II

Estimated Mammal Mortalities in Calif.(1980)

Species	Fishery	Number
California sea lion		
	Commercial Salmon Trolling	300
	Klamath River Gill Netting	7*
	Ocean Gill Netting	1187
	Squid Round Haul Net	10
	Anchovy/Mackeral Round Haul	20
	Trawl Fishery	10
	Total	1534
Harbor Seals		
	Klamath River Gill Net	22*
	Ocean Gill Netting	95
	Round Haul Nets	+?
Elephant Seals		
	Ocean Gill Netting	25
Harbor Porpoise		
	Ocean Gill Netting	15
	Round Haul Nets	+?
Pilot Whales		
	Squid Round Haul Nets	30
California Grey Whales		
	Ocean Gill Netting	3
Large Baleen Whales		
	Ocean Gill Netting	1
	Total All Mammals	1757

* - actual count, no estimate made.

+? - indicates that mortalities probably occur but no data are available to support actual estimates.

Source: Miller et al., 'California Marine Mammal Fisheries Interaction Study, 1979-1981', p.209

D. SHARK DRIFT-GILL-NET FISHERY

Gill-nets, or set nets as they were called prior to about 1920, are a type of fishing gear where the net hangs vertically in the water column stretched between a buoyant cork line near the surface and a lead line at the bottom. The net, normally constructed from cotton twine, is suspended by a series of floats attached to the cork line via extension

lines ranging from 1 to 3 fathoms in length (Figure 2.1). The size of modern day nets varies from 10 to 20 fathoms in depth and may reach lengths of up to 1000 fathoms. Mesh size, measured at the stretched distance from knot to knot, ranges from 10 to 20 inches with 14 to 16 inches being favored in Southern California. When fishing, the net remains attached to the boat at one end with a buoy and light at the other end. Occasionally, the boat may release itself from one end of the net and reattach at the other end if currents start to twist the net and adversely affect its fishing ability. Fishing operations are conducted at night with the net being retreived and set during daylight hours.

The drift-gill-net fishery for shark expanded rapidly in the late 1970's, growing from a fleet of 15 in 1977 to a current level of approximately 200 vessels. One of the reasons for this growth was the accidental discovery in 1979 that larger mesh (>10 inches), brought into the fishery to avoid unwanted fish caught by smaller mesh, would catch swordfish. This new species, not captured with the smaller mesh nets, carried a much higher market price than shark and brought new competition into the industry. Another reason was the growing need for additional sources of protein which expanded the market for shark, especially thresher and bonito. This increased competition for limited resources rekindled the animosity between the gill-net fishery and other fishing groups, primarily sportboat operators and harpoon fishermen, who applied pressure on the legislature to put an end to all gill-net fishing. Using political influence and lobbying these interest groups were able to push through legislation and place controls on the gill-net segment of the shark fishery. California Assembly Bill 2564 (September 1980), commonly known as the Kapiloff Bill,

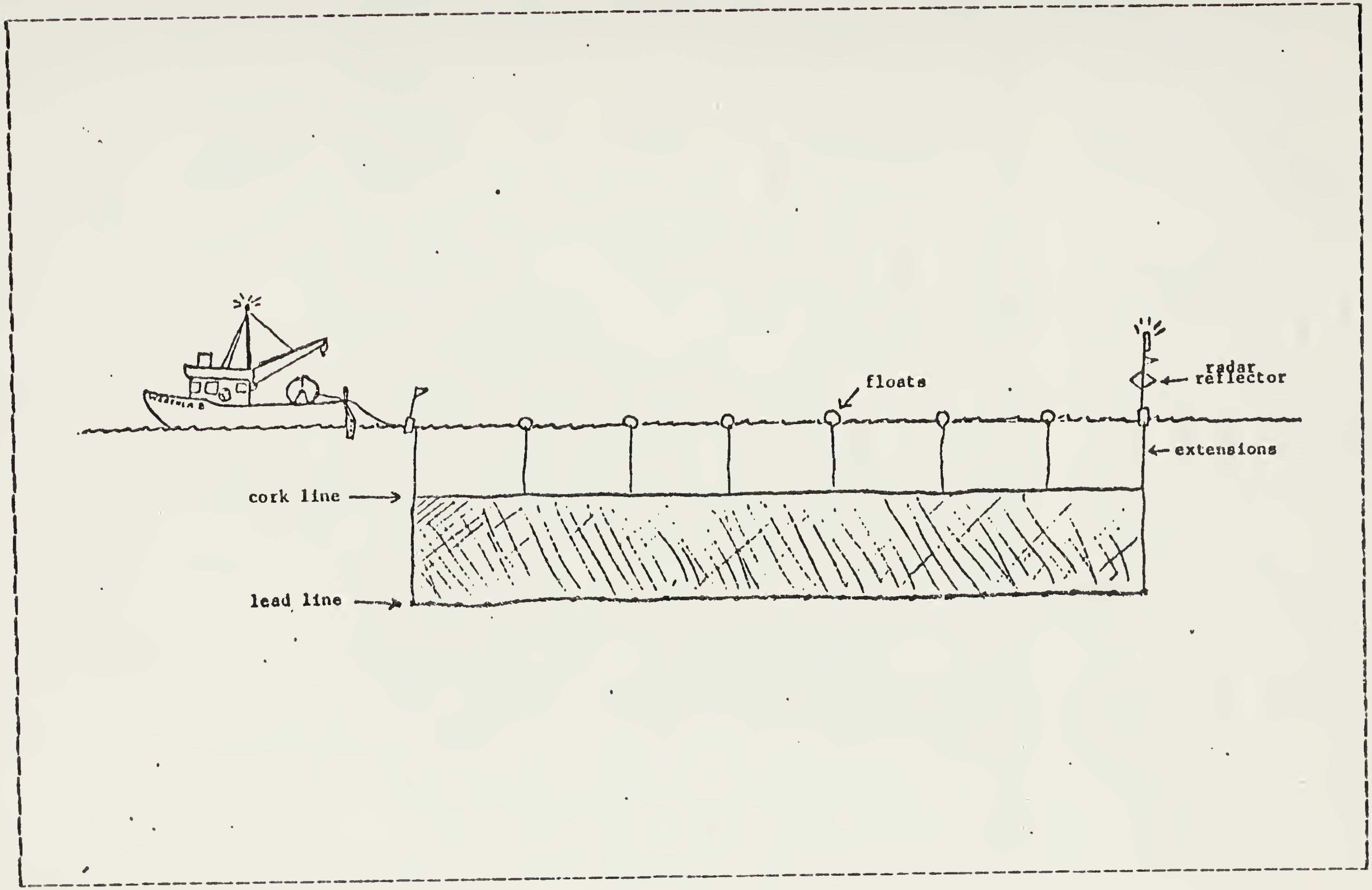


Figure 2.1 Configuration of Shark Gill-Net.

required fishermen to pass a proficiency test before receiving a permit, set a quota on the number of swordfish taken using gill-nets as 25 percent of the total in the harpoon fishery, and required each permit holder to submit a log of their activities to the California Department of Fish and Game. The bill also allowed the Department to place observers aboard gill-net vessels operating under a permit. The Kapiloff Bill remained in effect until September 14, 1982.

August, 1982, marked the beginning of more amendments to the Fish and Game Code due to the passage of Senate Bill 1573, referred to as the Beverly Bill. This recent legislation once again placed restrictions on the shark gill-net fishery operating off the Southern California coast, defined as the area south of Point Arguello. In addition to the previous regulations the Beverly Bill introduced several new requirements, the most significant being limited entry into the fishery and area closures. Effective April 1, 1984, the number of drift-gill-net shark and swordfish permits available are limited to a total of 150 vessels operating south of Point Arguello. Starting in 1983, a total closure is established of all gill-net fishing operations between February 1 and April 30. The bill also defines areas to be closed during specific times of year (Figure 2.2). The Beverly Bill remains in effect until January 1, 1988 unless the date is deleted or extended by later statute.

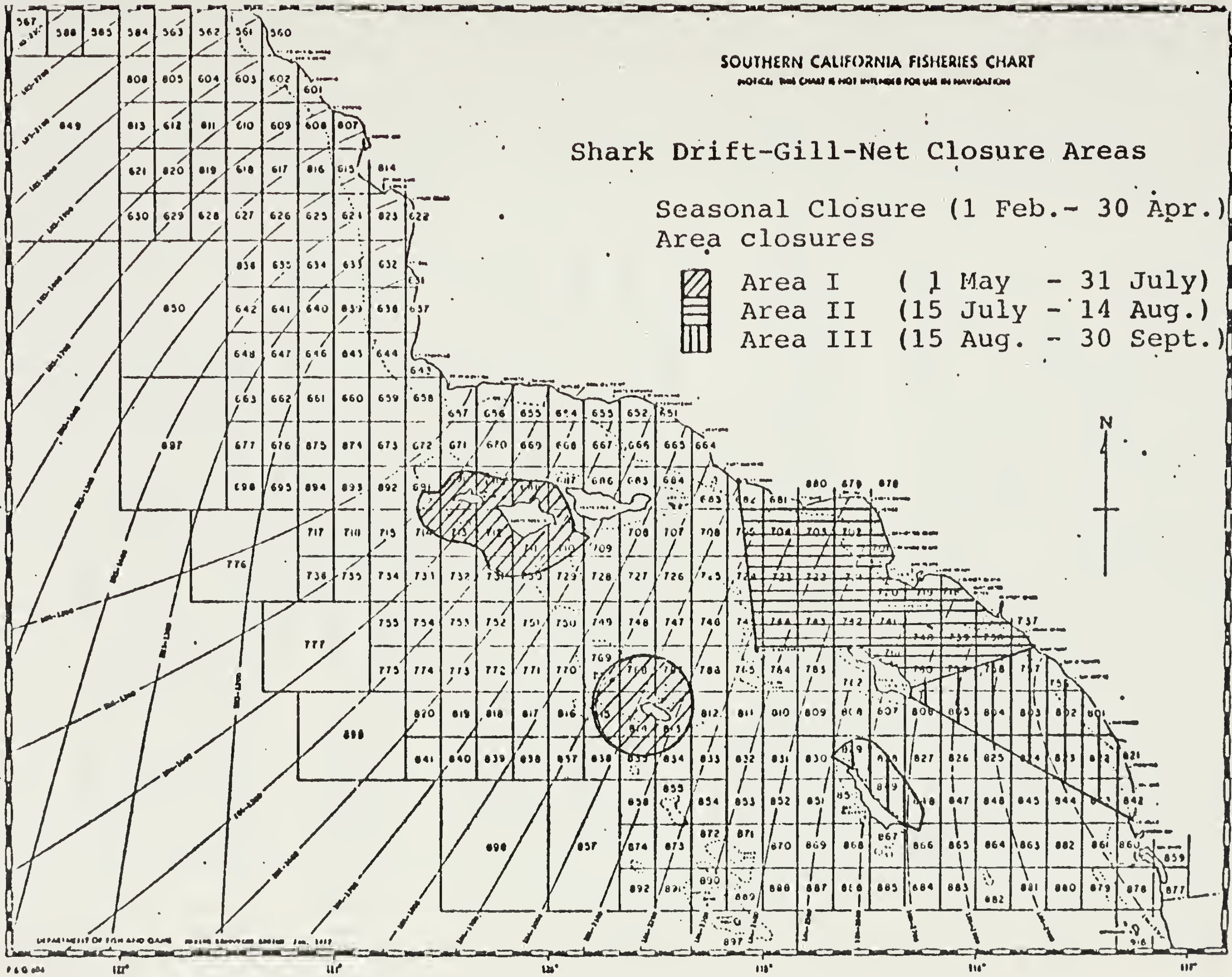


Figure 2.2 Closure Areas and Times Under the Beverly Bill.

E. STATE'S INTEREST IN MANAGING MARINE MAMMALS

The state of California is presently assessing the different management problems associated with specific species of marine mammals to determine if it should request return of management authority from the U.S. Secretary of Commerce. There are numerous reasons why the State is requesting return of management authority.

1. The 1981 amendments to the MMPA simplify the process whereby states can request return of management authority. The new streamlined approach now makes it quicker and easier for coastal states to regain this authority.
2. A desire by coastal states to manage resources within their boundaries instead of having that authority divided between the states and the federal government.
3. The idea that coastal states are better suited for the administration of the MMPA. Arguments in support of this idea are that states have more people in the field to conduct research, an enforcement network that can be instantly utilized, and a closer proximity to the problem so that constituents can be served more rapidly and effectively.
4. A simple permit system can be designed that is less confusing to the fishing industry, i.e., all permits would be controlled by the state.
5. If the state controlled all resources an ecosystems approach to management can be implemented instead of the species approach presently used. Such an approach could lead to more efficient management because the authority and regulatory bodies would all rest in one agency.

President Reagan and his administration have expressed a desire to reduce responsibility in federal programs that can be administrated at the state level. The 1981 MMPA amendments make it easier for California to regain management authority of different marine mammals, specifically the California sea lion. In order to obtain that authority the State must evaluate various management activities that might be implemented to regulate and monitor the incidental take of sea lions in the shark gill-net fishery. The purpose of this thesis is to identify different management activities available to the state of California, estimate the cost of implementing these activities given the State's present bureaucratic structure, and weigh the cost of each activity with its effectiveness in an effort to determine which activity would result in the most cost-effective management scheme.

III. COST ESTIMATES OF DIFFERENT MANAGEMENT ACTIVITIES

The incidental take of California sea lions in the shark gill-net fishery presents special problems to the State in developing an overall management plan. Before such a plan can be derived, different management activities specific to the sea lion and the gill-net fishery must be identified and studied. This chapter deals with five activities identified by the National Marine Fisheries Service as being of primary importance in developing a management plan. The management activities to be investigated are:

1. Assess the population level of California sea lions,
2. Assess the incidental take of sea lions in the fishery,
3. Limit the use of gill-nets by area and time of year to minimize the take of sea lions,
4. Determine the economic loss to the fishery in terms of gear and fish due to sea lion depredation, and
5. Estimate the cost of an accoustical playback unit and evaluate its effectiveness in detering sea lions and harbor seals from gill-nets.

These five activities are divided into three categories so that similar evaluation criteria can be applied within each category. The first category deals with assessing the present population status of the sea lion and determining if it is above or below the maximum net productivity level (MNPL). Category two involves assessing the incidental take of sea lions in the fishery operating in Southern California (south of Point Arguello). The final category incorporates the last three activities and is concerned with assessing economic losses to the fishing industry due to sea lion depredation and area closures mandated by legislation.

Each category is examined as a separate entity and comparisons made between the alternatives where applicable. The purpose of these comparisons is to determine which alternative is the most cost-effective for achieving the objectives of that category. Costs are estimated from the standpoint of what it would cost the state of California or the shark gill-net fishery, in terms of dollars, to implement the various activities. The categories are presented based on the order of the activity list and imply no priority of importance.

A. CATEGORY I: ASSESSING POPULATION LEVELS

The amended MMPA dictates that marine mammal populations must be at optimum levels before mitigating measures to reduce losses to fishermen can be taken. The difficulty is determining whether or not the California sea lion is at or near that optimum level, defined previously to be between the maximum net productivity level (MNPL) and the maximum population (K). In the past, determining the MNPL of exploited populations was based on a fixed percentage of K which was calculated to the pre-exploitation level from records of annual harvest and from an estimate of the current population size. In the case of the California sea lion, a complete record of harvests does not exist making these calculations impossible. A direct estimate of MNPL is also not possible because the current population size and the density dependent mechanisms that regulate the population are not known. To cope with these problems an analysis procedure, referred to as the dynamic response method (DRM), was developed and is presently being tested on California sea lions.

The purpose of the DRM is to determine if population levels are above or below MNPL, a reasonable lower limit to the OSP. The procedure is based on the dynamic relationship between population levels and recruitment rates (rates of reproduction plus survival into mature adults) shown in the production curve of the stock under study. Production curves are derived from annual pup counts in breeding colonies on various islands off Southern California. Presumably, MNPL is located at the peak of the production curve making it necessary to determine only if the present population level is above or below that point. If the population of a stock is at a level greater than MNPL, the stock will come to a stable equilibrium under a regulated quota harvest. Below the MNPL, a stock will not equilibrate under a quota harvest but will decline away from or grow toward the MNPL, depending on the harvest rate, production, and the population size. A more thorough discussion of the DRM is available in DeMaster <u>et</u> <u>al</u>., (1983).

Dynamic response methodology is discussed because it is presently the most efficient procedure for assessing present population levels of the California sea lion. To obtain data necessary for this assessment pup counts must be made on all the known haulout areas during the breeding season along with a survey of potential haulout regions for signs of expanding colonies. The following tables estimate what it would initially cost the State to obtain the counts.

The figures shown in Table III estimate what it would cost the State in the first year to send personnel and equipment to the different islands to count sea lions pups. It is assumed that equipment and vehicles needed for the counts are not available in the State's inventory and would have to be purchased. If the equipment were available, these costs could be recomputed using their present value (opportunity cost). These capital investments, shown as

equipment in the table (excluding gas/oil), would be incurred in the first year and in subsequent years only when the equipment needed replacement. Individual expenses, plus gas/oil from the equipment list, would reoccur each year a count was conducted. These costs, and capital expenses discounted over five years, are discussed in the cost-effectiveness analysis chapter to estimate expenses beyond the first year.

The estimated expenses shown in Table III, obtained from Dr. Douglas DeMaster, Leader, Coastal Marine Mammal Program, NMFS, are based on what it cost his program to conduct similar counts in the past. Transportation costs are estimated using round trip travel for personnel and equipment, excluding vehicles. Travel to San Clemente and San Nicolas Islands is conducted aboard a Navy operated aircraft and costs $72 per person. Vehicle transportation to these islands is aboard a barge chartered to transport large pieces of gear. The cost for each vehicle is estimated at $500. Getting personnel and equipment to San Miguel Island is estimated to cost $700 - $800 depending on whether an aircraft or boat are contracted. The least expensive cost ($700) is used in computing these estimates. Transportation to Santa Barbara Island is estimated at $800 for a charter boat since no landing areas are available on the island. This table is the basis for cost estimates made in the remaining four tables.

Tables IV through VII estimate what it would cost the State in the first year to collect sea lion pup count information at three different levels of effectiveness. The three levels are based on what Dr. DeMaster feels are necessary efforts to collect scientifically acceptable data. Costs shown in Table IV are tabulated using what Dr. DeMaster believes is the minimal effort necessary to collect useful information. Table V shows costs based on present

levels of study in the coastal program. The final values, shown in Tables VI and VII, are estimates of the costs for an enhanced level of effectiveness. Table VI shows costs to conduct a pup mortality study before the main haulout period in July. The reason for such a study is to obtain a better understanding of how pup births and deaths occur over the period of time prior to the main breeding season in July. Table VII estimates costs similar to Tables IV and V except that more replicate counts are made over fourteen days. There are no additional transportation costs figured for San Nicolas Island because counts begin on July 1 following the 42 day study on that island. All salaries are based on the cost of a seasonal employee hired by the State at the present rate of $4.53 per hour.

B. CATEGORY II: ASSESSING THE INCIDENTAL TAKE

Assessing the incidental take of California sea lions by the shark gill-net fishery can be performed in a variety of ways. Six different methods of collecting information to estimate take have been identified by the NMFS. Those techniques are:

1. Mandatory observer programs on all boats,
2. Mandatory observer programs on a sample of boats,
3. Voluntary observer programs,
4. Voluntary inspection of catch logs,
5. Dock surveys of fishermen, and
6. Using state vessels to monitor fishing operation on a sample of boats.

TABLE III

Estimated Operating Cost per Island

INDIVIDUAL EXPENSES	S.M.*	S.N.	S.C.	S.B.
Transportation				
air (round trip)	$700	$72	$72	$n/a
boat (round trip)	800			800
Food (daily)	6	6	6	6
Room (daily)	0	2	2	0
Seasonal Employee salary (daily)	36	36	36	36
EQUIPMENT				
Binoculars	100	100	100	100
Spotting scope	250	250	250	250
Manual counter	10	10	10	10
Data forms	10	10	10	10
Camera and lenses	500	500	500	500
Vehicle **				
purchase/maint.	n/a	2500	2500	n/a
transportation	n/a	500	500	n/a
gas/oil (daily)	n/a	5	5	n/a
Wall Tent	0	0	0	600
Total Equipment Cost (per 2 individuals)	870	3870	3870	870
Total Daily Cost (per individual)	44	44	44	44
Transportation (per 2 individuals)	700	144	144	800

* S.M.= San Miguel Isl. S.N.= San Nicolas Isl.
S.C.= San Clemente Isl. S.B.= Santa Barbara Isl.

** The vehicle cost is estimated only as a reasonable approximation of possible expenses.

In addition to the island counts an aerial survey is required to assess the remaining islands for haulout regions.

Source: Personal interview with Dr. Douglas DeMaster, Leader, Coastal Marine Mammal Program, NMFS, SWFC, December 1982. Costs are 1982 dollars.

TABLE IV

Cost Estimates Providing Minimal Effectiveness

A ground count on San Miguel and San Nicolas Islands requiring two seasonal employees for five days at each island and aerial surveys of the remaining islands. Work is to be performed in mid-July.

1) Costs to Conduct Ground Counts		
San Miguel		
Transportation	$ 700	
Daily expenses		
Food	60	
Salaries	360	
San Nicolas		
Transportation	144	
Daily expenses		
Food & shelter	80	
Gas/maintenance	25	
Salaries	360	
Equipment		
Binoculars	200	
Spotting scope	250	
Counter	20	
Forms	20	
Camera w/ lenses	500	
Vehicle	3000	
Total Ground Count		$5,719
2) Aerial survey		
Estimated to require 8 hrs. at $250/hr.		2,000
Total Minimum Effort		$7,719

The estimated cost to implement each of these techniques is presented under the assumption that a similar level of effectiveness is achieved using each method, except for method four as discussed below. Analysis of these alterna-

TABLE V

Cost Estimate Providing Present Effectiveness

Replicate ground counts on all four islands requiring two employees for seven days on each island plus aerial surveys of the remaining islands. Work is to be performed in July.

1) Cost to Conduct Ground Counts

San Miguel		
Transportation	$ 700	
Daily expenses		
Food	84	
Salaries	504	
San Nicolas		
Transportation	144	
Daily expenses		
Food & shelter	112	
Gas/maintenance	35	
Salaries	504	
San Clemente		
Transportation	144	
Daily expenses		
Food & shelter	112	
Gas/maintenance	35	
Salaries	504	
Santa Barbara		
Transportation	800	
Food	84	
Salaries	504	
Equipment		
Binoculars	200	
Spotting scope	250	
Counter	20	
Forms	20	
Camera w/ lenses	500	
Vehicles	6000	
Wall tent (S.B.Isl.)	600	
Total Ground Counts		$11,856

2) Aerial Survey

Estimated to require 4 hrs. at $250.0 /hr.	1,000
Total All Counts	$12,856

TABLE VI

Cost Estimate Providing Enhanced Effectiveness

A pup mortality study on San Miguel and San Nicolas from May 15 to July 1, four replicate counts on all the islands using two groups of observers for fourteen days each island, plus aerial surveys of the remaining islands. Pup counts are done in July.

1) Pup Mortality Study (42 days)

San Miguel	
Transportation	$ 700
Daily expenses	
Food	504
Salaries	3024
San Nicolas	
Transportation	144
Daily expenses	
Food & shelter	672
Gas/maintenance	210
Salaries	3024
Total Study	$8,278

Continued in Table VII

tives is conducted assuming a fixed effectiveness, therefore, cost of implementation is the evaluating criterion. Only substantial costs, such as employee salaries and special expenses are estimated to make comparisons between the alternatives.

1. Mandatory Observers on All Boats

The original purpose of this method was to place an observer on at least one fishing trip of all vessels operating south of Point Arguello under a shark gill-net permit between May 1 and August 31. Such an approach is not possible, however, due to the limited size and generally cramped living quarters aboard the vessels participating in

TABLE VII

Continuation of Enhanced Effectiveness

2) Pup Ground Counts (14 days)		
San Miguel (last 2 wks of July)		
Transportation	$ 700	
Daily expenses		
Food	168	
Salaries	1008	
San Nicolas		
Transportation	0	
Daily expenses		
Food & shelter	224	
Gas/maintenance	70	
Salaries	1008	
San Clemente		
Transportation	144	
Daily expenses		
Food & shelter	224	
Gas/maintenance	70	
Salaries	1008	
Santa Barbara		
Transportation	800	
Food	168	
Salaries	1008	
Equipment		
Binoculars (4)	400	
Spotting scopes (2)	500	
Counters (4)	40	
Forms	40	
Cameras (2)	1000	
Vehicles	6000	
Wall tent	600	

Total Ground Counts		$15,180
Total Study and Counts		23,458
3) Aerial surveys		
Estimated to take 4 hrs. at $250 /hr.		1,000

Total All Counts		$24,458

the fishery. Bedford (1983A) found that out of eighty-two vessels operating under a dual permit (gill-netting and

happening simultaneously) thirty-three (40 percent) could not accomodate an observer. Using this information, and the fact that the number of boats allowed to operate in Southern California under a permit is restricted (150), the maximum number of vessels on which an observer could be placed is set at ninety. The estimates also assume: 1) trips average five days each with a two-day turn around in between, 2) seasonal employees would be trained as observers, 3) observers make one trip every nine days, and 4) the time period involved is four months (120 days).

Based on these assumptions a minimum of 7 observers (90 boats divided by 13 trips per observer) would be required if an observer could be placed on a new boat when the observer was available. Since vessel and observer availability may not coincide an extra observer is assumed necessary and sufficient to obtain the desired number of trips. Therefore, eight observers are used for computing cost. Employee travel to and from the vessel is not included nor are other costs, such as data forms and miscellaneous equipment which do not fluctuate between the alternatives compared. Training time is included in the four months of employment. Per diem, based on the State's present rate of $18 per day, is included to account for the time when boats offload the observer late at night away from the homeport or observers have to stay in an area waiting for a particular boat. Such occasions are estimated to occur on half the planned trips or an average of six times to each observer. A food allowance of $15 per day is paid to vessels carrying observers.

Cost:

Employee salary	$23,193
Food (455 sea days)	6,825
Per diem	864

Total	$30,882

2. Mandatory Observers on a Sample of Boats

This method is similar to the previous one except that data is only collected from a representative sample of available vessels. The sample size desired is then the determinant number for computing the required number of observers and cost of implementation.

Computing Sample Size

The purpose of computing a sample size is to determine how many observer trips are required to collect data that is statistically significant. Sample size is computed based on data collected by Miller et al., (1982), who estimated the mean (u) sea lion catch per day to be 0.28 (range 0.08 - 0.48) using a sample (n) of 177 observations. Using a standard error (e) of 0.1, believed to be the minimal acceptable level, the standard deviation (s) is estimated at:

$$s = (e)(\sqrt{n})$$
$$= (.1) \times (\sqrt{177}) = 1.33.$$

The coefficient of variation (v) is used as a relative indicator of precision of the estimate. It is the quotient of the standard deviation divided by the mean. Based on this estimated (s) and a .25 coefficient of variation, the number of daily observations is computed as:

$$v = \frac{e}{u} = \frac{s/\sqrt{n}}{u}$$

$$n = \left(\frac{s}{(v)\,(u)} \right)^2$$

$$n = \left(\frac{1.33}{(.25)\,(.28)} \right)^2$$

$n = (19)^2$ = approximately 360 daily observations.

Assuming the minimally-acceptable coefficient of variation to be 0.5, the sample size would be:

$$n = \left(\frac{1.33}{(.5)\,(.28)} \right)^2$$

$n = (9.5)^2 = 90$ daily observations.

Obviously, the cost to achieve the larger sample size (n=360) should be considerably higher than the cost to achieve the smaller sample size (n=90). For comparison, the cost to collect 360 observation days is estimated for this section. Assumptions made in the previous section are the same with the exception that only six observers are required to complete the necessary trips (72). The smaller sample size is used as a lower bound to estimate cost in the voluntary observer section, which immediately follows.

Cost:

Employee salary	$17,395
Food	5,400
Per diem	648

Total	$23,443

3. <u>Voluntary Observer Programs</u>

The difference between this method and the mandatory programs is that observers only go on vessels where they are invited by the owner. Due to the present regulations on the gill-net fishery, the belief by fishermen that observers ultimately lead to more regulations, and recent court decisions concerning the legality of observers, it is doubtful whether enough sample trips could be conducted to obtain a large enough sample. Assuming ninety daily observations could provide useful data and that this number would be invited by the fishermen, costs are estimated as before using two observers and 18 trips (90 observations / 5 observations per trip). It is emphasized that 90 observations would only provide data of minimally acceptable accuracy and that it is possible fishermen would not volunteer their vessels for even this number of trips since they have little incentive to do so.

Cost:

Employee salary	$5,798
Food	1,350
Per diem	216

Total	$7,364

4. <u>Voluntary Inspection of Catch Logs</u>

Present legislation mandates that permit holders operating a gill-net fishing vessel maintain a catch log. The purpose of the log is to record catch information, such as species caught, location, time, etc. There is also a place on the log to record marine mammals entangled in the net. Evidence has shown that the data recorded on target species, such as thresher shark and swordfish, is fairly

accurate but that sea lion entanglements are not normally recorded. In fact, of the 2420 days of fishing logged between September 1980 and September 1981 not one sea lion was recorded as being entangled (Miller et al., 1982, p. 142). Because of this total non-compliance by fishermen in obtaining incidental take data, no estimates of costs to review the logs are presented. The inspection of these logs does not appear to be a viable alternative for obtaining take information.

5. Dock Surveys

Dock surveys are designed to collect catch information from fishermen by personal interviews at the docks when they offload their catch. Unlike catch logs, direct interviews are purported to provide fairly accurate information. In a study of the salmon trolling fishery, Miller observed that:

> "Interview data proved that even though many fishermen professed openly that they did not trust us or that we were wasting our and their time, they still gave us valuable and accurate information" (Miller et al., 1982, p.8).

Assuming this observation remains consistent in the shark gill-net fishery, dock surveys could prove to be a means of collecting data on incidental take.

The following computations are based on a number of assumptions. 1) The period of study is May 1- August 31, (120 days), 2) Seasonal employees would be trained to collect the data, 3) Interviews would be conducted in all ports where catch is offloaded. 4) Data probably won't be collected from all boats but a representative sample can be obtained. Again, travel costs and miscellaneous expenses are not included. Per diem is computed as before.

Based on these assumptions an estimated four observers are deemed necessary to collect the data, one each in the areas of Santa Barbara, Los Angeles, Long Beach, and San Diego.

Cost:

Employee salary	$11,596
Food	0
Per diem	432

Total	$12,028

6. <u>Use of State Vessels to Monitor Fishing Operations</u>

This final technique involves placing observers on enforcement vessels operated by the California Department of Fish and Game under the supposition that observers would not be placed on commercial fishing vessels. Data on take is collected by placing observers on patrol craft, ferrying them to a fishing area, and deploying them in skiffs to monitor the retrieval of the gill-nets. The success of this procedure is dependent on the presumptions that patrol boats can carry two observers in addition to the operating crew, the boats are equipped with a skiff for one observer, fishing vessels set their nets in centralized areas according to fish concentrations, and the areas and vessels sampled are representative of normal fishing operations.

The costs computed in this method are based on using two observers for a four months period who ride on State vessels when space is available and the boats are operating in gill-net fishing areas. Therefore, vessel costs are not included in these totals. The warden assigned to each vessel is also considered to be a trained observer, making three observers available on a vessel. A sample size of 360 observations is expected requiring one hundred and twenty

days at sea. Daily food allotments for observers is set at $15 per day, the same rate as in the commercial fleet. No per diem is included because observer accommodations are provided on the vessel. An additional cost of $3,000 is included to cover the cost of adding a skiff and motor to the vessel for a second observer. Unlike the other costs shown below, the $3,000 capital investment is not an annual expense so it cannot be added to the others. An annual amount can be computed, however, if the amount is discounted over its usefull life. Assuming a 10 percent discount rate, continuous cash flow, and a five year useful life of both the skiff and motor, the average annual cost is $754, based on a present value factor of 3.977 (OMB, 1972). Fuel and oil for the skiff is estimated at $6.25 per day (5 gallons x $1.25 per gallon) for 120 days.

Cost:

Employee salary	5,798
Food (120 days)	1,800
Per diem	0
Skiff & motor (discounted)	754
Fuel & oil (additional skiff)	750
Total	9,102

C. CATEGORY III - ECONOMIC IMPACT OF SEA LIONS

This final category, made up of the last three activities presented earlier, deals with estimating the economic cost to the State and fishermen as a result of sea lion interaction. The first activity, limiting the use of gillnets by area and time of year to minimize the take of sea

TABLE VIII
Summary of Costs

1)	Mandatory observers - all boats	30,882
2)	Mandatory observers - boat samples	23,443
3)	Voluntary observers	7,364
4)	Voluntary inspection of catch logs	n/a
5)	Dock surveys	12,028
6)	Observers on state vessels	9,102

lions, uses the area closures specified in the Beverly Bill to estimate the State's cost to enforce the closures and the potential losses to the shark gill-net fishery resulting from closing the areas. These two subactivities, and the remaining activities are:

1. Cost to the state to enforce the area closures mandated by the Beverly Bill,
2. Economic loss to the fishermen resulting from area closures,
3. Economic loss of gear and fish resulting from direct sea lion interaction, and
4. The value of an acoustical playback device.

1. State Cost to Enforce Closure

The Beverly Bill, as discussed previously, established areas of closure to all shark gill-net fishing operations off Southern California at different times of year (Figure 2.2). The burden of enforcing these regulations rests with the California Department of Fish and Game which maintains an enforcement network throughout the State. Presently, there are four vessels and one aircraft based

south of Point Arguello used to monitor the closure areas. The operating cost of these vehicles is used to compute cost estimates to enforce the closures. Each closure area is presented separately.

The hourly operating costs for the aircraft and vessels used in these computations were obtained through personal communication with Inspector R. Goodrich, CDF & G, Long Beach Office. The hourly rates were estimated based on the total cost to operate each vessel in 1982 divided by the total hours of operation. To obtain a more precise estimate of the vessels' actual cost the salaries of employees aboard each vessel were subtracted from the hourly rate. These expenses were considered to be a sunk cost to the State and not affected by the closure. Even with this reduction, the hourly rates used are probably more than actual costs, making the final cost estimates biased upward.

a. Seasonal Closure: February 1 - April 30

Overall surveillance of the area south of Point Arguello is assumed to be conducted by the aircraft, making two, four-hour flights a week (personal contact with Inspector Goodrich). If suspected violators are spotted a patrol vessel is called out to investigate. The number of times each vessel must respond to a call is unknown, so a best estimate (13) is used (range: 0-26). This number is based on the aircraft making 26 flights during the 13 weeks of the closure. The cost per trip of each vessel is based on an average round-trip distance within the vessel's jurisdiction, the vessel's cruising speed, and operating cost per hour. The values used for estimating cost are shown below. The average number of calls for the vessel <u>Albacore</u> is assumed to be approximately half that of the other vessels because it is primarily responsible for offshore areas.

Vessel	Homeport	Distance (n. m.)	Speed (kts)	Cost/hr.	#Calls
Yellowtail	Ventura	80	18.0	$126	13
Marlin	Long Beach	70	8.5	$126	13
Albacore	Long Beach	130	18.5	$157	7
Skipjack	San Diego	90	19.0	$ 66	13

Using these estimates, costs are computed as:

Aircraft (104 hrs. @ $128/hr.)	$13,312
Yellowtail	7,280
Marlin	13,489
Albacore	7,723
Skipjack	4,064

Total	$45,868

Range: Low = $13,312 (no vessels used)

High = $77,321 (number of calls doubled)

b. Closure Area I: May 1 - July 31

There are two areas designated in this closure. The first consists of approximately 615 square miles surrounding San Miguel and Santa Rosa Islands. This area falls under the jurisdiction of the vessel Yellowtail for which all cost estimates are computed. Area two encompasses approximately 315 square miles surrounding San Nicolas Island. Vessel costs to enforce this area are based on the operational capabilities of the vessel Albacore. Aircraft surveillance is estimated at three hours per day, twice a week.

Vessel	Homeport	Distance	Speed	Cost/hr.	#Calls
Yellowtail	Ventura	110	18.0	$126	13
Albacore	Long Beach	150	18.5	$157	7

Using these estimates, costs are computed as:

Aircraft (78 hrs.@ $128/hr.)	$ 9,984
<u>Yellowtail</u>	10,010
<u>Albacore</u>	8,911

Total	$28,905

Range: Low = $ 9.984 (no vessels called)

High = $46,553 (number of calls doubled)

c. Closure Area II: 15 July - 14 August

This area covers approximately 1445 square miles extending along the coast from Point Mugu south to Dana Point and seaward to Santa Barbara and Santa Catalina Islands. Cost estimates in this area are based on the operational capabilities of the vessel <u>Marlin</u> using an average round trip distance of sixty miles and four responses to calls. Aircraft surveillance is estimated at one and a half hours per day, twice a week.

Using these estimates, costs are computed as:

Aircraft (12 hrs. @ $128./hr.)	$1,536
<u>Marlin</u>	3,558

Total	$5,094

Range: Low = $1,536 (no vessels called)

High = $8,651 (number of calls doubled)

d. Closure Area III: 15 August - 30 September

Area three, estimated at approximately 1,035 square miles, is also divided into two sections. One section is triangular shaped with its borders running from Dana Point to the south end of Santa Catalina Island to La Jolla. Section two lies along the northeast coast of San Clemente Island extending seaward ten miles. Vessel juris-

diction in this area is assumed to be split between the vessels *Marlin* and *Skipjack* with the *Skipjack* having responsibility for the section off San Clemente Island and the southern half of section one. The average round-trip distance for the *Marlin* and *Skipjack* are estiamted at seventy and one-hundred-twenty miles respectively. Aircraft surveillance is estimated at two and one-half hours per day, twice a week.

Vessel	Homeport	Distance	Speed	Cost/hr.	#Calls
Marlin	Ventura	70	8.5	$126	6.5
Skipjack	San Diego	120	19.0	$ 66	6.5

Using these estimates, costs are computed as:

Aircraft (32.5 hrs. @ $128./hr.)	$ 4,160
Marlin	6,745
Skipjack	2,709

Total	$13,614

Range: Low = $ 4,160 (no vessels called)
High = $23,059 (number of calls doubled)

Based on the assumptions and criteria presented, it is estimated that it would cost the State somewhere between $28,992 and $156,594, with a best estimate of $93,481, to enforce the areas of closure established in the Beverly Bill. Of these costs $28,992 are attributable to aircraft operations leaving $64,489 (range: 0 - $126,602) as the cost to deploy enforcement vessels (Table IX).

As stated previously, these estimates are believed to be biased upward but it is not known by how much. In comparison, the CDF & G estimated it cost approximately $47,296 for vessel enforcement operation connected with the shark gill-net fleet throughout California for ten

TABLE IX

Summary of Closure Costs

	Aircraft	Vessel Low	Vessel Estimate	Vessel High
Seasonal Closure	$13,312	$0	$32,556	$64,009
Area I	$ 9,984	$0	$18,921	$36,569
Area II	$ 1,536	$0	$ 3,558	$ 7,115
Area III	$ 4,160	$0	$ 9,454	$18,909
Total	$28,992	$0	$64,489	$126,602

Aircraft + Estimate = $ 93,481

Aircraft + High = $156,594

months last year (Goodrich, 1983). Six vessels were involved between April 1 and January 31, 1982. It is not known, however, how much total time was spent at sea or how much each vessel was used. The cost does indicate, however, that the best estimate computed above appears to be a reasonable estimate.

2. Economic Loss to Fishermen Resulting from Closures

The closure areas mandated by the Beverly Bill took effect February 1, 1983. Consequently, little information is available to assess the economic value of fish lost to the shark gill-net fleet as a result of the closures. In order to get some idea of what that the loss might be, upper and lower bound cost estimates are computed based on two diverse assumptions about the effects of closing the areas.

The lower bound, resulting in the minimal amount of fish loss, assumes that sharks and swordfish sought by the fishermen are uniformly distributed and that moving to a new area will not affect the total catch. Arguments can be made that overall costs to the fishermen would increase due to additional running time, more competition in a smaller area, etc., but these costs are believed to be insignificant and are eliminated here. Based on this assumption a lower bound loss is estimated to be zero, using the rationale that fishermen can move to a new location, outside the closure, and still catch the same value of fish as they would have caught had the areas not been closed.

At the opposite end is the upper bound where maximum fish loss occurs. Here the assumption is that sharks and swordfish concentrate in specific areas and that all catch not taken due to area closures is non-recoverable and a direct loss to the fishing fleet. Thus, catch taken in closure areas prior to 1983 constitutes an economic loss to the fishermen that cannot be recovered by fishing elsewhere.

The following computations are based on monthly catch data for the three target species sought by fishermen; bonito shark, thresher shark, and swordfish. All other species are assumed to be incidental and have only a minor impact on the total catch value. Monthly catch data for thresher sharks and swordfish in 1981 was provided by Dennis Bedford (CDF & G) and is shown in Appendix A. The number of bonito sharks caught during 1981 is not available so catch estimates for the species are made based on a ratio of total pounds of bonito landed to total pounds of thresher landed in 1981 (approximately 14 percent).

Catch information for thresher sharks and swordfish within each closure area is tabulated by superimposing the closed region on each monthly chart and summing the catch in each region. Within each reporting block, catch is assumed

to be uniform allowing catch estimates for portions of blocks covered by the closure. For example, if the closed region covers approximately fifty percent of a reporting block, catch within the closed region is estimated to be half the total catch of the block. This procedure produced the number of species caught within each closed area. The only data available for the seasonal closure (February 1 - April 30) south of Point Arguello pertains to thresher sharks caught in April 1981. Using this data, and the fourteen percent ratio for bonito sharks, a lower limit for species caught in the closed area is estimated.

	Thresher	Bonito	Swordfish
Closed Area	78	11	0
Area I	852	120	0
Area II	140	20	16
Area III	31	5	28
	----	---	--
	1101	156	44

The economic value of this catch is estimated based on the average dock price per pound in 1982 and the average dressed weight of each species in 1981 (Bedford, 1983B).

	Ave. Price/lb.	Ave. Weight
Thresher shark	\$ .80 (.60 - 1.00)	133
Bonito shark	\$ .75 (.50 - 1.00)	25 (20-30)
Swordfish	\$3.00 (2.00 - 4.00)	140

Using this information, the loss per area is computed as:

	Thresher	Bonito	Swordfish	Total
Closed Area	\$ 8,299	\$ 206	\$ 0	\$ 8,505
Area I	\$90,653	\$2,250	\$ 0	\$92,903
Area II	\$14,896	\$ 375	\$ 6,720	\$21,991
Area III	\$ 3,298	\$ 94	\$11,760	\$15,152
	--------	------	-------	-------
Total	\$117,146	\$2,925	\$18,480	\$138,551

Based on these two assumptions the economic loss to fishermen resulting from area closures is estimated somewhere between $0 and $138,551, assuming an equal intensity of fishing regardless of catch.

3. Economic Loss of Fish and Gear Due to Sea Lion Interaction

Sharks and swordfish are the target species desired by the shark gill net fishermen. Of these, sharks have not been reported or observed as being eaten by sea lions while caught in the net. Swordfish depredation, however, has occurred and is estimated to amount to about 1.2 percent of the total swordfish take in drift-gill-nets, estimated at approximately 24,000 pounds from December 1980 to November 1981 (Miller *et al.*, 1982, p. 149). Based on these findings the approximate loss in 1981 was 290 pounds. Assuming this loss is fairly constant and the average price per pound of swordfish is three dollars, the estimated loss in 1982 is $870.

In the same study, Miller estimated that gear loss averaged about $2.50 per set yielding a total value of $600 for 1980. Assuming a ten percent inflation rate, the loss in 1982 dollars amounts to $726. These results suggest that the total estimated loss in 1982 was approximately $1600.

4. Value of Acoustical Playback Unit

The acoustical playback unit is an electronic device designed to emit a high frequency sound signal capable of deterring sea lions from areas where it is played. In theory, the device could be installed on commercial fishing vessels to keep sea lions away during fishing operations. At present, the unit is still in the developement stage having met with varying success in field tests. The unit could, however, be used in the future to reduce losses if

the cost to purchase and operate were not prohibitive. That cost is not known at this time. However, it is doubtful if the fleet could be equipped with the units for less than $1,600, which is the total estimated loss to fishermen due to sea lion interaction.

IV. SENSITIVITY ANALYSIS

Sensitivity analysis is a technique used by decision analysts to examine the effects of changing some of the underlying assumptions or parameters of a particular study. The technique is applied here to assess the sensitivity of assumptions and estimated costs in the various categories to determine if a decision concerning the effectiveness of an activity might be altered should certain assumptions be changed. Each category is addressed separately with a discussion of how the analysis was conducted and the results.

A. CATEGORY I: ASSESSING POPULATION LEVELS

Costs estimated in the three levels of effectiveness are based on the first year operating costs per island (Table III), an assumed number of days and personnel on each island, and an estimated number of flight hours at a fixed rate. These assumptions and estimates are examined to see how their fluctuations might influence the final results.

The first step in this analysis is to identify the costs in Table III that could make a significant difference if the estimate was found to be in error. Of these costs, vehicle, transportation, and equipment are the largest costs with potentially the greatest impact. The cost for each of these units, however, is fixed in all three levels of effectiveness so that changing them will not make a relative difference between the alternatives. Therefore, they are not considered sensitive to the final decision.

The second part of the analysis deals with looking at variable parameters within each level and estimating how high they would have to go before the total cost at that effectiveness level could be comparable to the next higher level. No fluctuation is expected in the number of personnel needed on each of the islands; it is fixed at two. The parameters examined are days on the island and aerial survey costs. If the counts required at the minimium effectiveness level were increased to seven, the same number of days estimated for the median level, the costs would increase $330. Even with this rise, and an increase in the aircraft cost from $250/hr. to $300/hr., the aircraft would have to fly 22.7 hours before the total cost would compare to the next higher level. Such an increase seems unlikely.

Using this same approach on the present program effectiveness level similar results occur. If nine days on each island are required to obtain replicate counts, costs would increase $708. The aircraft would then have to fly 36.3 hours at the higher hourly rate before costs would be comparable to the enhanced effectiveness level. At fourteen days, twice what is expected, costs would increase about $2478 and would still allow 8.9 hours of flying using the higher rate. Again, more than twice what is expected. Such increases also appear to be unlikely.

This comparative analysis shows that assumptions and estimates made in computing the costs in this category are not very sensitive to the final results. In other words, it is unlikely that circumstances surrounding each level of effectiveness would change enough to compare with the next level of effectiveness. Each level, therefore, is considered to be independent of the others and should be judged based on the level of effectiveness obtained for a given expenditure of money.

E. CATEGORY II: ASSESSING THE INCIDENTAL TAKE

The costs shown in the six different methods of collecting incidental take data reveal two separate groupings. At the upper end of the cost scale are the first two methods, the mandatory placing of observers on all available boats or on a sample of boats. At the lower end are the remaining methods; voluntary observer program, dock surveys, and observers on State vessels. This grouping will exclude method four found earlier to be ineffective. This analysis examines the two groups.

Costs at the upper end of the scale are driven primarily by salary which is a function of the number of observers needed to collect data. Total salary under the mandatory observer method is based on a nine day cycle for trips and an extra observer to reduce scheduling problems. If these assumptions are changed to a seven day cycle and no spare observer, the method could be conducted using six observers. Under these assumptions, the cost would be comparable to the second method of placing observers on a sample of boats. Costs for the first method would still be slightly higher than costs for the sampling method, however, because the number of observation days would be greater, approximately 455 versus 360.

The outcome variability shown above makes it difficult to separate the two alternatives based solely on cost. Therefore, costs for each method are estimated to be similar, ranging somewhere between $23,000 and $31,000 for a large number of observations (360 - 455).

At the lower end of the scale are costs estimated for the last three methods. Again, the primary cost is salary based on the expected number of observers needed to collect the data.

Cost estimates for the voluntary observer program are based on a minimal sample size of ninety observations. Essentially, this represents the lower limit of method two, mandatory observers on a sample of boats. If the sample size were increased, i.e. the number of observations increased, cost would also rise. That cost would increase to the upper end of the cost scale depending on how many observations were desired. In actuality, this method could cost less than estimated because the 90 observations desired might not be achieved under a voluntary program.

Dock surveys, shown to cost approximately $12,000, could range as high as $15,036 and as low as $9,021 depending on the number of observers employed. It is felt that at least three observers are needed to effectively survey the docks.

The final cost estimate, calculated using observers on State vessels, is at the lower end of the scale because vessel operating costs are not included. The rationale for this is that the observer program is considered a piggy-back operation and not part of the vessel's primary mission. If this assumption was ignored and the vessels were used for 120 observation days, the cost to the State would be well over the highest amount estimated in this category. In fact, it would cost approximately three to four times as much to collect 360 observations using State vessels as it would using a mandatory observer program if the cost to operate the vessels were included. Costs are estimated based on the vessel operating rates shown in category three.

The analysis of placing observers on commercial vessels reveals that the area most sensitive to cost centers around the number of observations needed to collect useful data. This factor drives the number of observers required to collect the data which in turn drives cost. Graphing these results shows that there is a near-linear relationship between the desired number of observations collected by

observers aboard commercial vessels and cost. Thus, sample size must first be determined before cost can be assessed. Figure 4.1 shows this relationship and can be used to estimate cost once the number of observations has been determined.

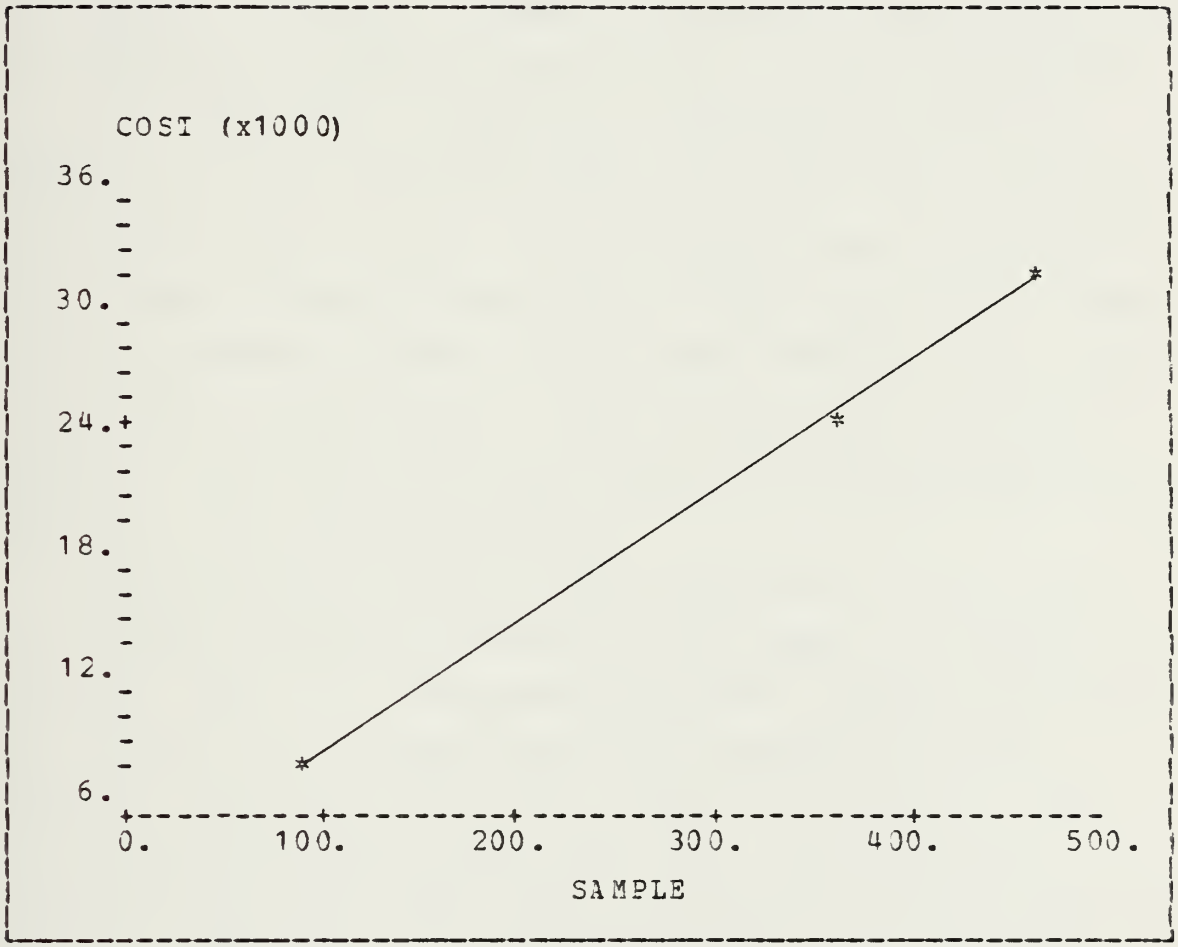


Figure 4.1 Cost vs Number of Observations.

C. CATEGORY III: ECONOMIC IMPACT OF SEA LIONS

The four cost elements discussed in this section are not alternatives to be evaluated to find the most cost-effective method of achieving activity objectives. They do, however, provide valuable incite as to the economic impact of California sea lions on the State and the shark gill-net fishery in Southern California. Because alternatives cannot be compared, each cost element is examined separately to see how different assumptions could affect the cost estimates.

Cost estimates to enforce the closures are computed based on a number of assumptions. The first is that the aircraft is the primary mode of surveillance and operates an average of twice a week. If the flights were increased to three times a week the lower end of the range would increase by fifty percent driving the mean and high end of the range upward by an equal amount. Since this is not the present policy, an increase such as this is difficult to justify. However, should such an change occur, it is recognized that the costs would rise accordingly.

Vessel operation costs appear sensitive in two areas, the average distance traveled and the number of responses to aircraft calls. If the average distance traveled by each of the vessels in a closure area were increased by fifty percent, the total vessel cost would rise $32,240, given that other parameters remain the same. This amount is roughly half of the mean total vessel cost showing that the distance traveled is a sensitive assumption. Similarly, the number of times a vessel is called out to investigate an aircraft sighting is also sensitive, as shown by the low/high range in each closure area ($0 - $126,602).

Given these two sensitive estimates, a 'worst case' scenario could be devised consisting of the increased travel distance and a response frequency equal to one call every

time the aircraft surveys. Such a scenario would drive the cost to approximately $158,842, almost two and a half times the present estimate. The other elements in these calculations, vessel speed and cost per hour, are felt to be reasonably accurate estimates and are treated as constants, recognizing that the hourly cost is biased upward due to miscellaneous expenses included in it.

The second cost element, economic loss to the fishermen resulting from area closures, is primarily sensitive to the two basic assumptions concerning how the closures affect catch effort. These assumptions alone establish a loss ranging from $0 to $138,500, depending upon which assumption is believed.

Another assumption that could affect the upper end of the range is the procedure used to compute the 1981 catch within the closure areas. Recall that the catch within the recording blocks was assumed to be uniform throughout the block and that the estimated number caught was dependent upon the percentage of the block covered by the closure area. If the catch distribution is assumed to be nonuniform and concentrated within the closure area, the upper end of the range would increase $33,223, making the new limit $171,774. All other elements used in the computations are believed to be reasonable estimates and not sensitive to the total.

The third element, economic loss of fish and gear, is computed based on the findings of a previous study (Miller et al., 1982). Even if the percentages and estimates were off enough to double the estimated loss the total amount does not appear to be significant. Therefore, none of the assumptions here are assumed to be sensitive to the overall outcome.

The final cost element, value of an acoustical playback unit, has no cost estimates so there are no assumptions. Thus, sensitivity analysis is not useful at this time.

V. COST-EFFECTIVENESS ANALYSIS

The information provided in the previous chapters can now be analyzed to estimate probable costs of the different alternatives. Each of the activities, and alternatives where applicable, are evaluated according to how they fulfill their objectives.

A. CATEGORY I

The costs associated with the three levels of effectiveness are primarily attributed to how many pup counts are conducted on an island, how many islands are involved in the count, and whether or not a pup mortality study is conducted. Assuming a mortality study is not conducted, the range of costs for the three levels of effectiveness in the first year is reduced: $7,719 - $15,324 ($15,180 + $144 for transportation). If it is also assumed that the State wants more than a minimal effort in its base year study, the minimal effectiveness level can also be eliminated. This narrows the cost even more making the difference $2,468 ($12,856 - $15,324). Given this difference, it is believed that four replicate counts on all the islands is the best alternative, for the first year of study. It provides the State with twice as much data as the present level while increasing cost less than 20 percent. The pup mortality study, although important, is a separate research project that should be evaluated on its own merits.

The above analysis is based on comparing first year costs at three levels of effectiveness. Included in these figures are capital expenses, such as vehicles, binoculars, etc., that could be discounted over their useful life so

that average annual costs between the levels could be compared. These costs, plus the expenses that occur annually for each count, allow a comparison where the first year capital expenses are averaged over time. Assuming a 10 percent discount rate, continuous cash flow, and a useful life of five years, a present value factor of 3.977 can be used to convert capital expenses at the beginning of a five year period to equivalent annual expenditures in each of the five years by dividing 3.977 (OMB, 1972) into the one time capital expense. Table X shows the average annual discounted costs for the three levels of effectiveness.

TABLE X

Annual Discounted Cost for Effectiveness Levels

	Annual Cost	Capital Cost	Discounted Cap. Cost	Annual Cost
Minimal	$1,729	$3,990	$1,003	$2,732
Present	$4,266	$7,590	$1,908	$6,174
Enhanced Counts	$6,600	$8,580	$2,157	$8,757
M. Study*	$8,278			
Enh.Total	$14,878		$2,157	$17,035

* Mortality study (42 days)

The average annual cost computed (annual cost + discounted capital cost) shows an increase of $2583 (about 30 percent) each year to collect twice as much data under the enhanced level as under the present level of effectiveness, if mortality studies are not included. This difference is believed to be worthwhile, at least for the

first year or two, to establish a strong data base. Thus, both discounting and direct cost comparisons indicate that the enhanced level is the most cost-effective approach, at least initially.

B. CATEGORY II

Sensitivity analysis reveals that the most important factor in this category is the number of observations needed to collect statistically reliable data. Sample size computations show that at least 90 observations are needed with more being preferred. Assuming that 90 observations provide only minimally acceptable data and obtaining that number is doubtful using observers on vessels volunteering to carry them, the voluntary observer program is eliminated. It is also believed that the dock surveys have a greater potential for being biased and provide less accurate data than direct observation. Therefore, dock surveys are also eliminated. Of the two mandatory programs, it is difficult to determine which one is more cost-effective because they cost about the same under certain assumptions and both attain a high number of samples. Observations over 360, however, appear to be of only marginal value. Thus, the maximium number of observations needed is set at 360 which could be collected using either mandatory method and cost the State around $23,000 - $31,000, depending on the number of observers employed. Both methods are considered viable for collecting a reliable sample of observations.

The final decision comes down to choosing between some form of mandatory observer program and placing observers on State vessels. Since fewer observers are needed using State vessels the cost is less, assuming the vessel operating expenses are a sunk cost to the State. If these costs are not sunk then this method would cost about three to four

times as much because the cost to operate enforcement vessels is more than the cost to hire observers. Thus, under this assumption, placing observers on State vessels would be less cost-effective than placing them on commercial vessels.

C. CATEGORY III

Unlike the previous categories the activities discussed here do not have alternative methods of achieving a desired objective so that a cost-effectiveness analysis of alternatives is not possible. In this section each of the cost elements are analyzed with respect to their accuracy as an average cost estimate of the activity. The overall effect is the economical impact on the State and the shark gill-net fishery resulting from sea lion interactions.

The costs estimated for the State to enforce the closure area are based on the CDF & G's present policy of monitoring closure areas. That policy of using an aircraft for surveillance and calling a vessel to investigate possible violations is believed to be the most efficient means of enforcement given limited funds to operate all enforcement vehicles. Because of these limited funds, and an understanding of how operations must be juggled to stay within that limit, no alternative procedures are evaluated. The cost limits shown here are believed to be reasonable estimates of what it might cost the State to monitor the closed areas. A more precise estimate should be made in October 1983 after all areas are reopened and actual costs can be assessed.

Economic loss to the fishermen as a result of area closures ranged from $0 to $138,551, depending on one's assumptions about how the closures affect fishing. An argument can be made that the lower limit should be $8,505

because this is the value of catch lost due to closing the region south of Point Arguello (1 February - 30 April). Discounting what the lower limit might actually be, it is estimated that the shark gill-net fishery will incur a loss in 1983 as a result of closing fishing areas, assuming the environmental conditions and fishing effort are the same as they were in 1981. Since neither of these parameters are static it is difficult to precisely predict what the loss will actually be.

Fish and gear loss due to sea lion depredation does not appear to be a major problem to the fishery and costs the State nothing. The costs are estimated to show what it might cost the State to reimburse the fishermen for their losses as an alternative to closing fishing areas. It is not suggested that this is a viable alternative for solving the problem, given legal ramifications, political pressures, and a host of other troublesome areas, but is offered only to provide a perspective when considering the cost of other alternatives.

The last activity, acoustical playback unit, shows promise for the future but offers no immediate solutions. If the device proves successful at keeping sea lions away from fishing areas it could greatly reduce mortality and economic losses to the fishermen. The cost of purchase and implementation would have to be less than the present loss incurred or there would be little incentive for the fishermen to utilize the unit. The State might consider supplementing the cost of the unit or providing some other incentive, such as opening fishing areas to fishermen using the devise, as a cost-effective alternative to what it is presently doing.

VI. CONCLUSIONS AND RECOMMENDATIONS

Interactions between the California sea lion and the shark gill-net fishery cause economic loss to the fishermen and mortality to sea lions. Because of these problems California is considering a request to regain management authority of the California sea lion so that it may interface marine mammals and fisheries management within the State's jurisdiction. One aspect of this process is assessing the cost and effectiveness of management activities specific to the sea lion/gill-net fishery interaction problem. This thesis studies five activities whose understanding and evaluation are felt to be an important part of developing an overall management strategy. Based on this evaluation, conclusions and recommendations for each of the categories identifying the five activities are discussed.

Assessing the population level of California sea lions to determine if they are above or below OSP can be done most efficiently using the dynamic response method previously discussed. The basis for this method is collecting pup count data on the islands known to be rookeries plus aerial surveys of the surrounding islands. The analysis conducted in category one indicates that four replicate pup counts (14 days) on all four islands plus aerial surveys are the most cost-effective means of collecting reliable information. It is estimated that this method will cost the State approximately $16,180 in the first year or $9,750 a year over the first five years using discounted capital expenses. A pup mortality study is also recommended although forty-two days of continuous data may not be necessary.

Assessing the incidental take of sea lions in the gill-net fishery can be performed using data collected by five different techniques identified in Chapter Three. Assuming a desired sample size of more than ninety observations the most cost-effective means of collecting data is a mandatory observer program on a sample of boats. This method is recommended because it is impossible to place observers on all boats due to cramped living conditions and the cost to operate State vessels is higher than the cost to hire observers. The cost to conduct such a program is a direct function of the desired sample size (90 - 360 observations). A rough estimate of what it could cost the State to send observers on commercial vessels can be obtained from Figure 4.1.

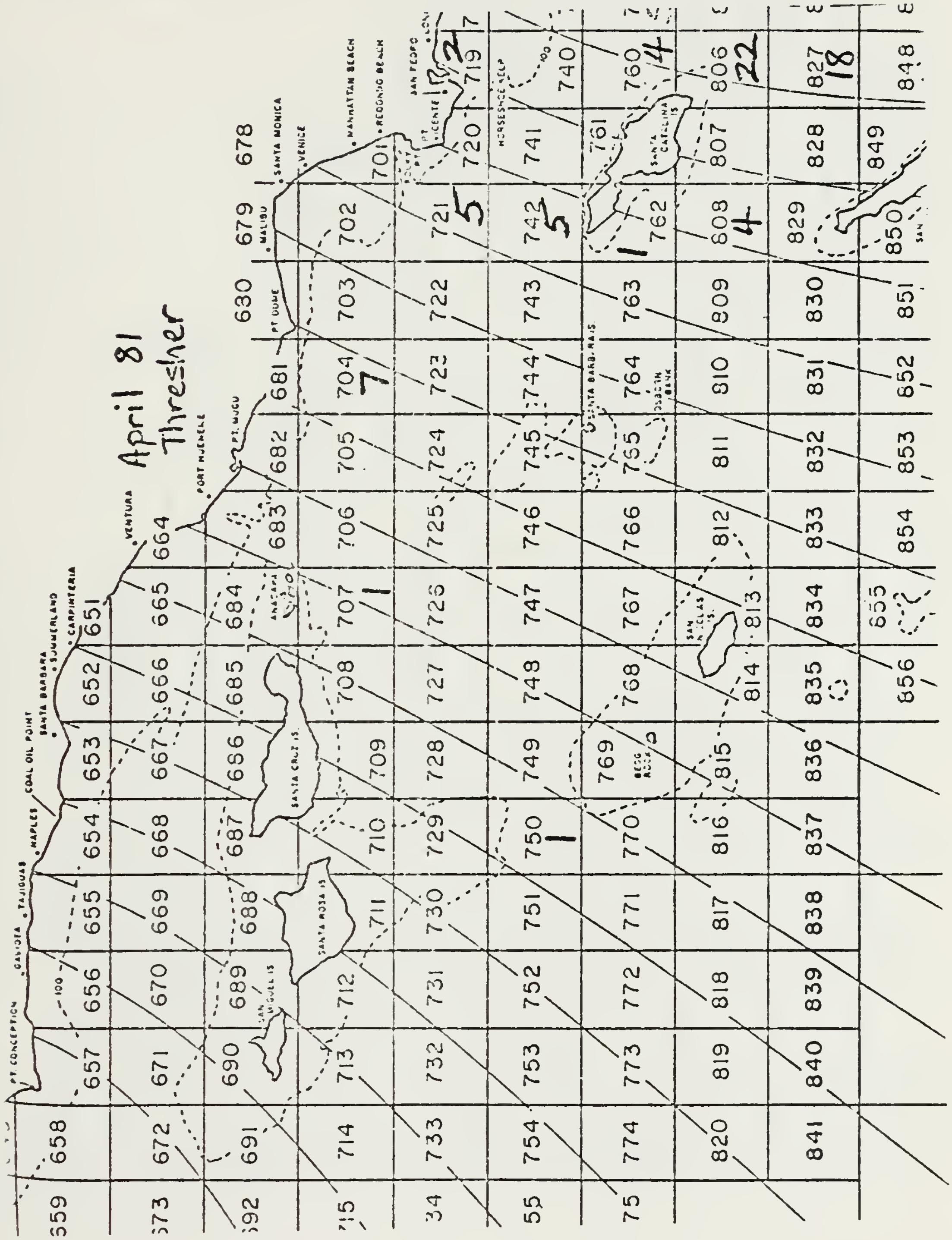
The final category deals with the last three activities identified. Costs associated with limiting the use of gill-nets by area and time of year were estimated from two perspectives using the closure areas mandated by the Beverly Bill. The first perspective estimated what it would cost the State to enforce the area closures using an aircraft and four enforcement vessels. Average costs here are estimated at about $29,000 for aircraft operations and $64,500 for vessel operations (range $0 - $126,600) depending on how many times the vessels respond to calls from the aircraft. It is recognized that these estimates may be slightly high due to the inflated hourly rates used in computing costs but they are believed to be reasonably close to actual expenses. The second perspective is an estimate of what it could cost the gill-net fishery, in terms of fish lost, due to closing the fishing areas. Estimates of the losses range from $0 to about $138,500 depending on assumptions concerning catch distribution, fishing effort, and environmental conditions.

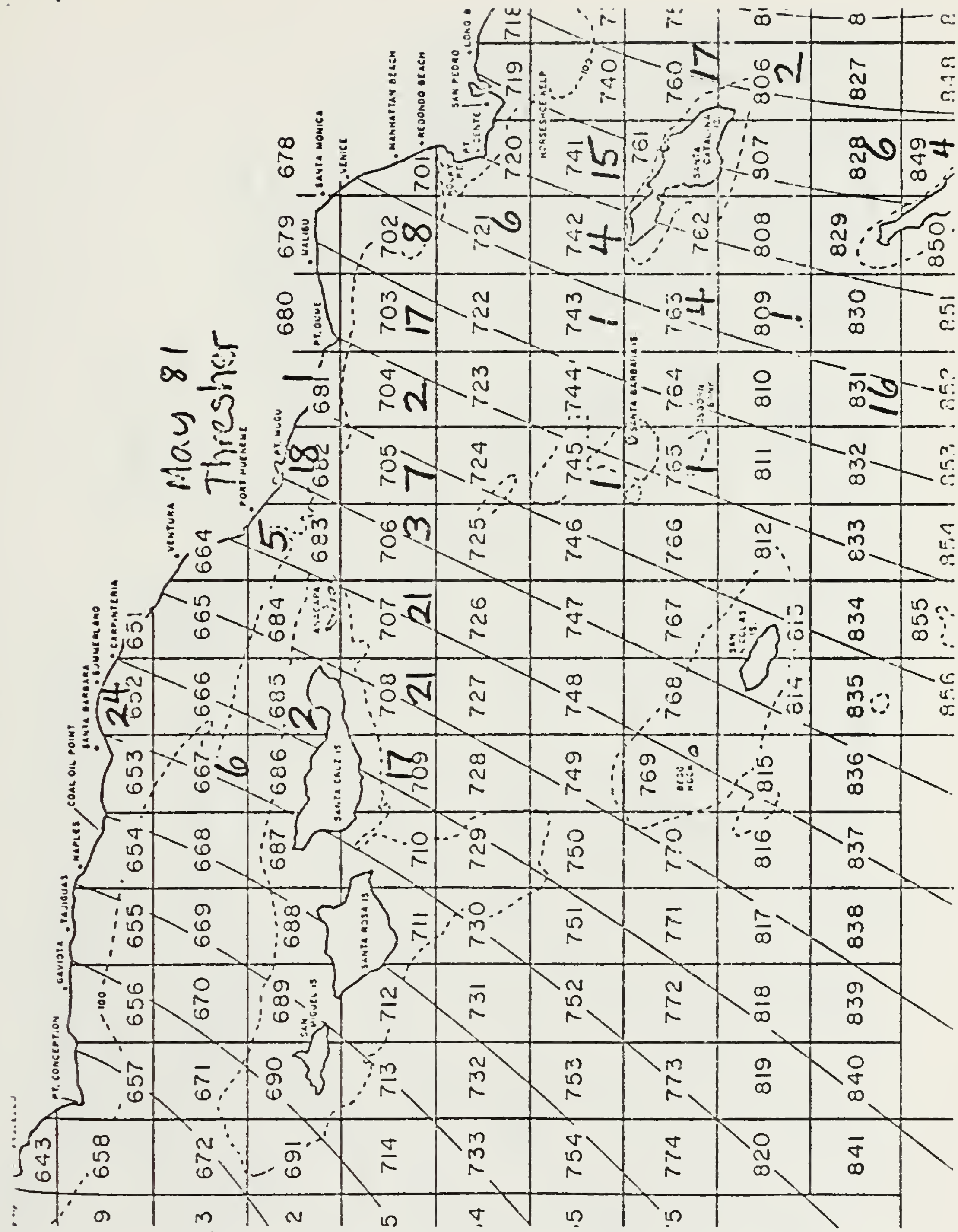
Fish and gear lost to the fishery due to sea lion depredation does not appear to be a significant cost, estimated at about $1600 for the industry. This figure should be kept in mind, however, when the cost to purchase and operate an acoustical playback unit is finally determined. If fishermen are going to use the device to reduce mortality the cost should be comparable to losses incurred due to depredation or an alternate means of incentive must be provided. If the device were perfected and found to perform as designed, and there was an advantage to the fishermen to use it, sea lion mortality and costs to all parties involved could be reduced in the future.

This study was conducted to provide decision makers in the California Department of Fish and Game and the National Marine Fisheries Service with cost-effective criteria on which to judge the value of different management activities related to interactions between the shark gill-net fishery and the California sea lion. Hopefully, this information will give managers additional insight into the many aspects of various activities and allow them to develop an optimal management plan when requesting return of managment authority.

APPENDIX A

THRESHER SHARK AND SWORDFISH CATCH PER BLOCK AREA

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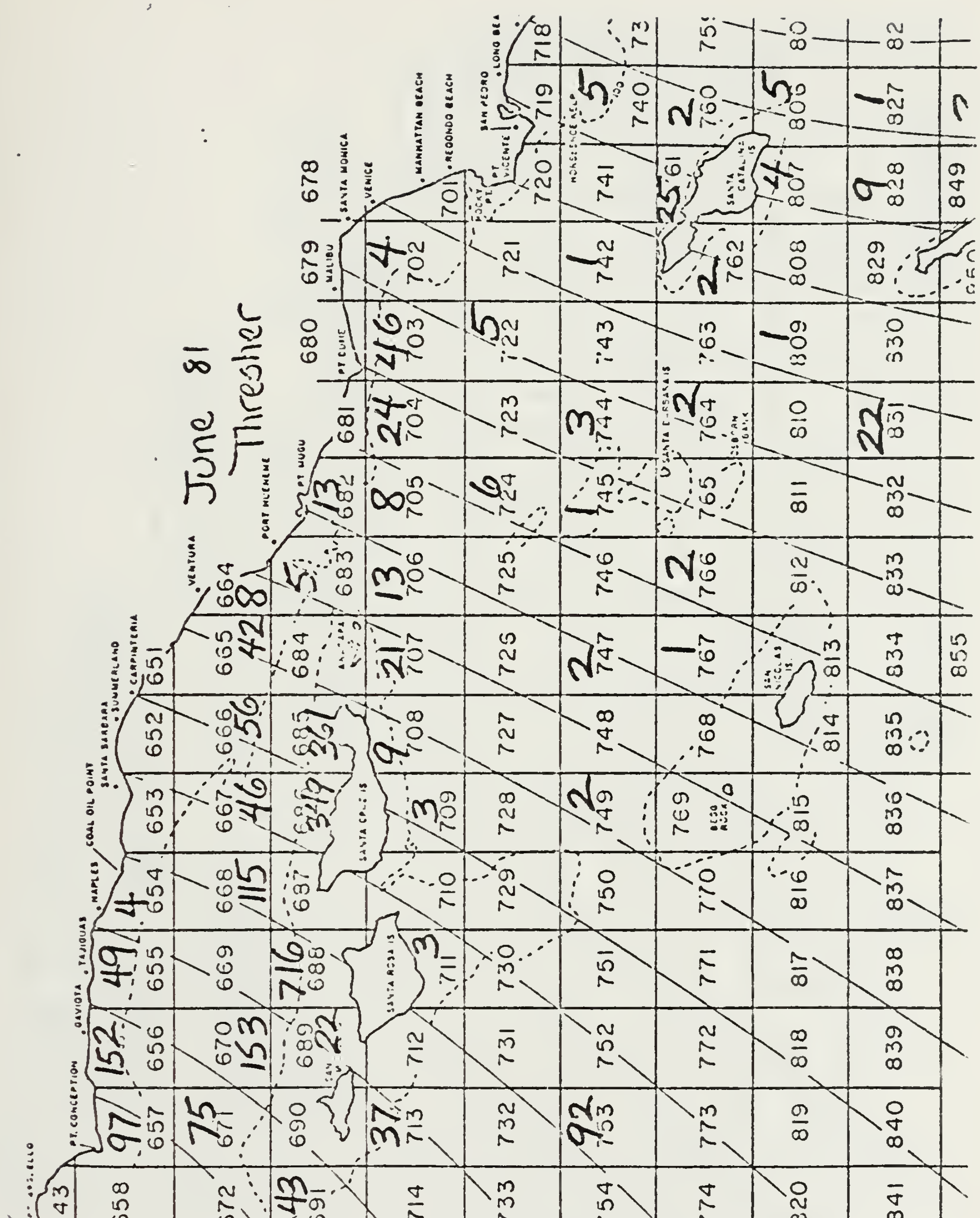
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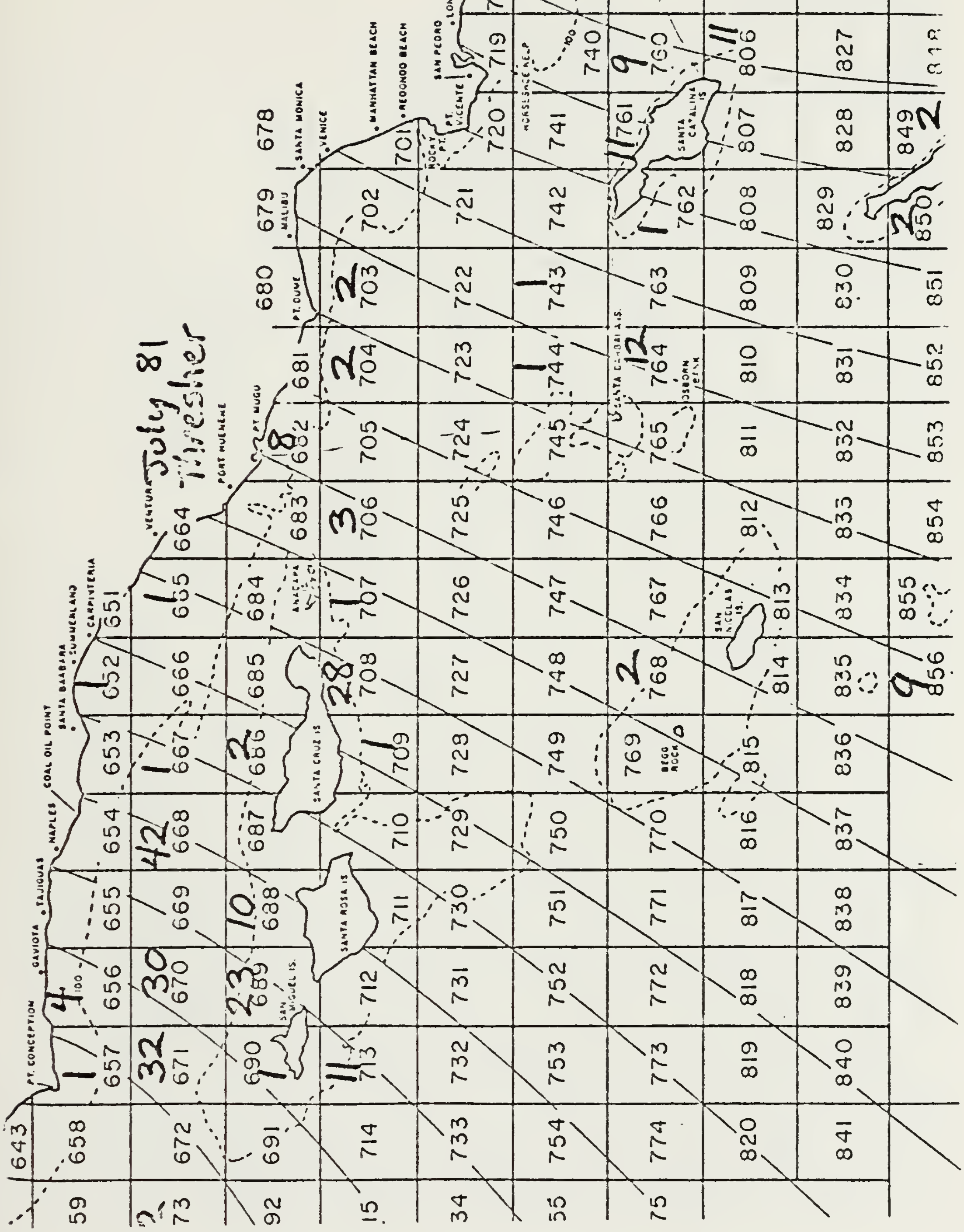
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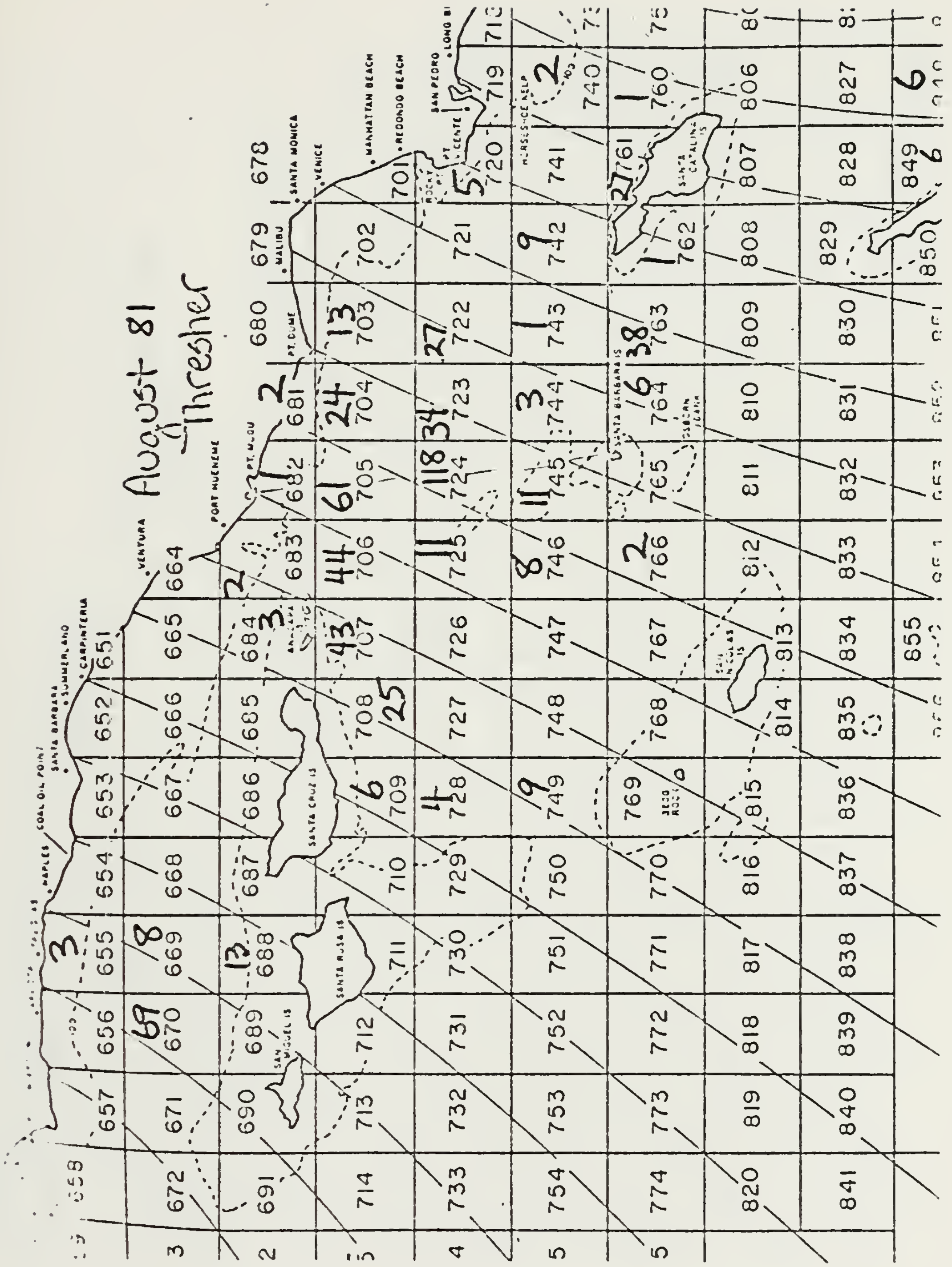

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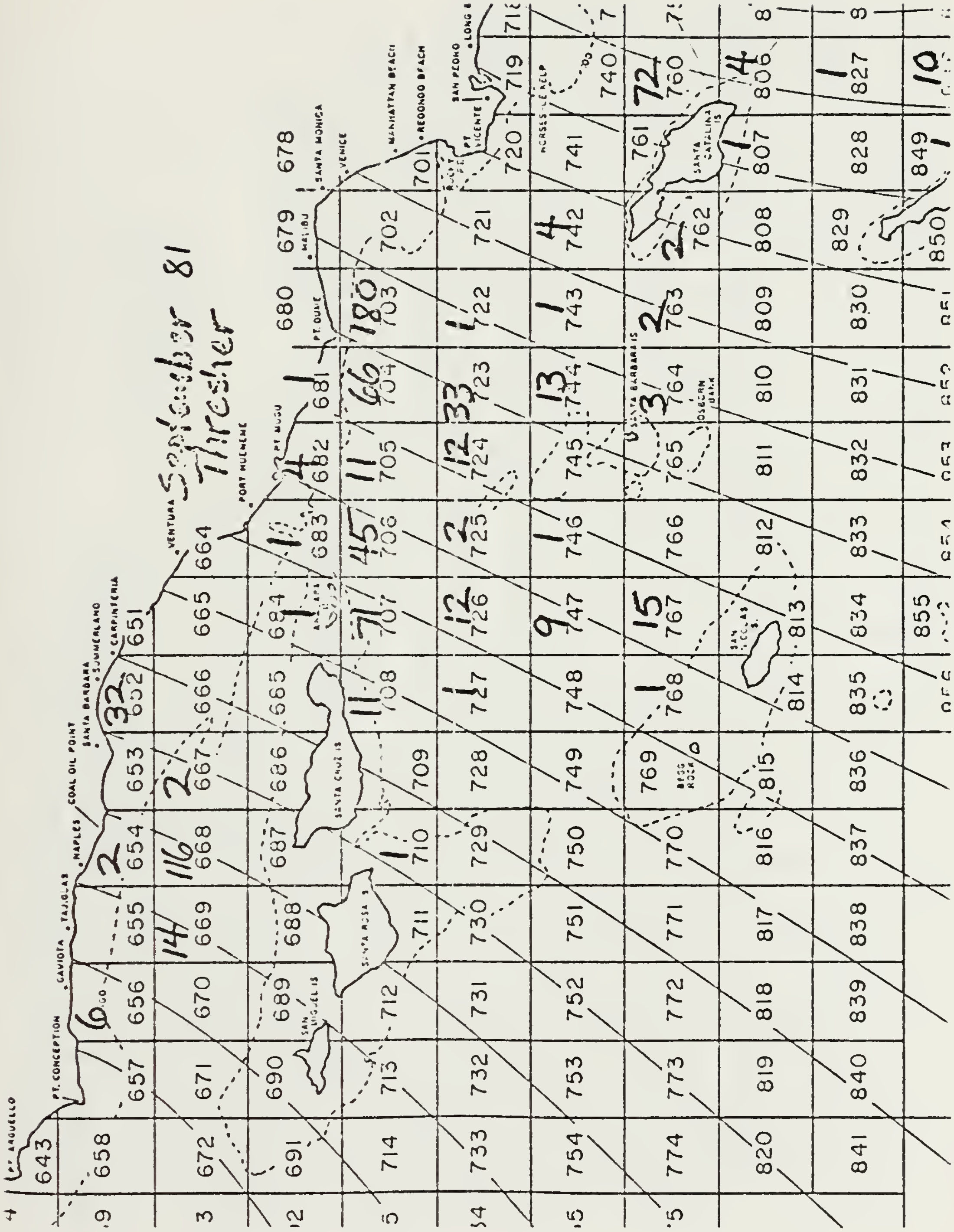
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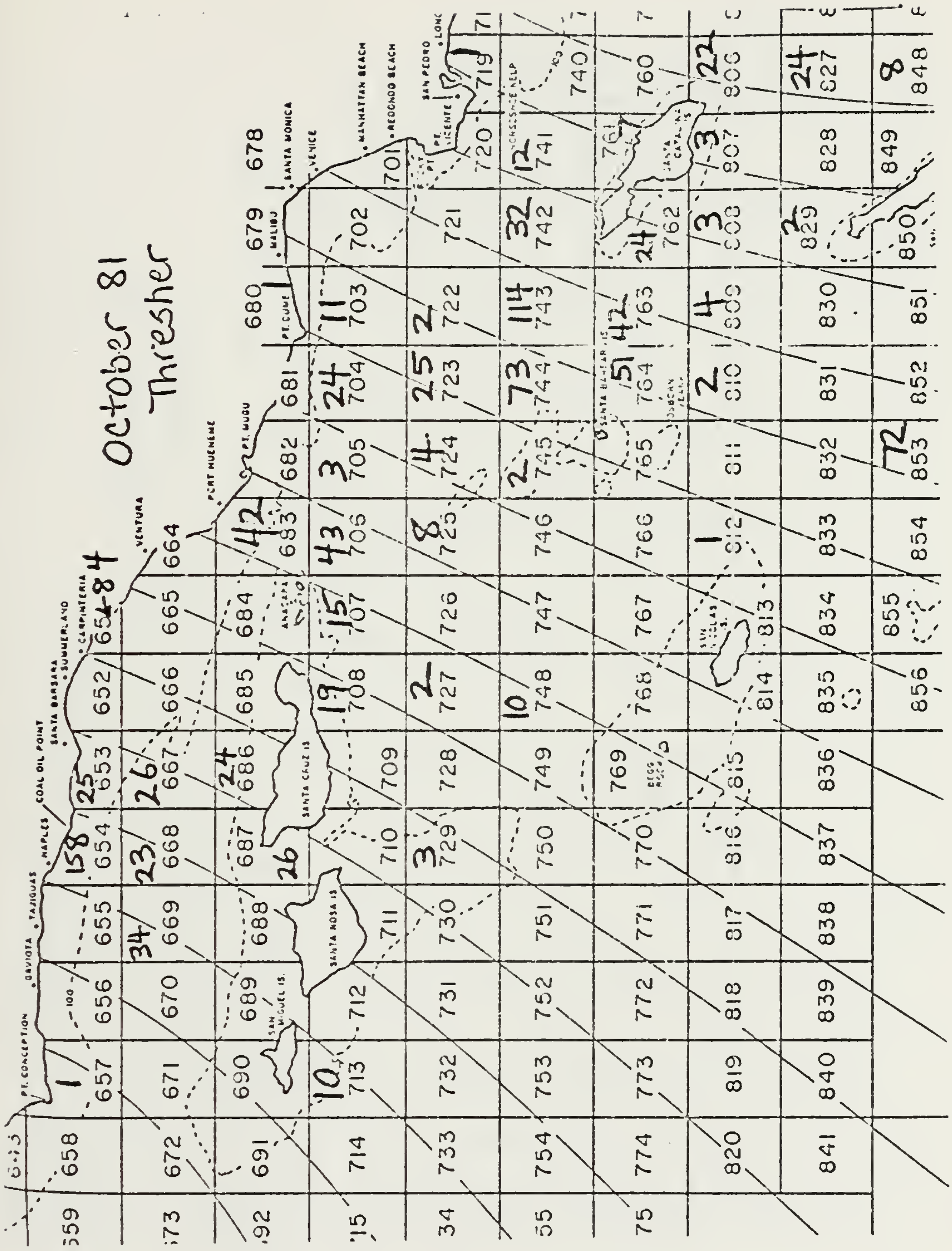
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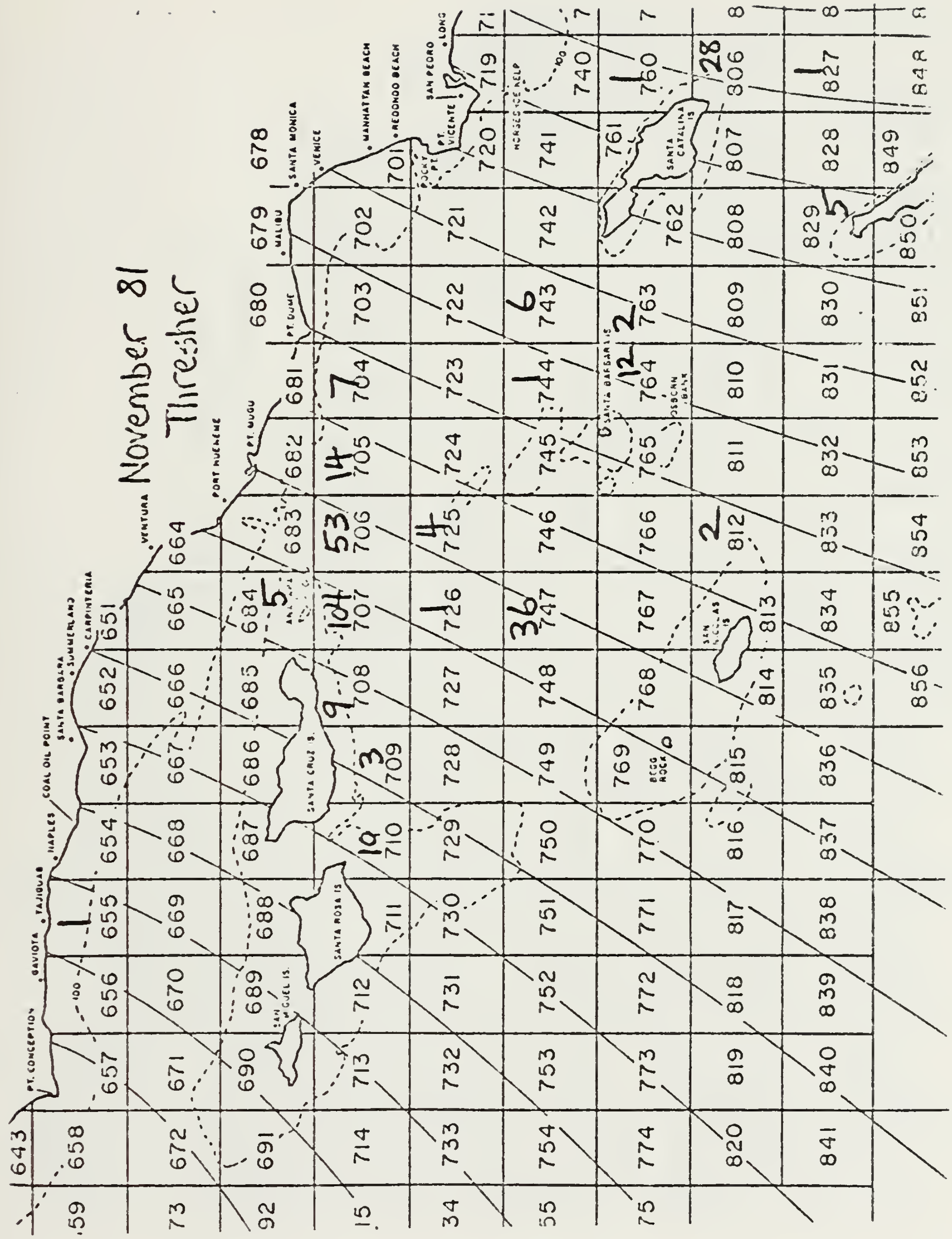
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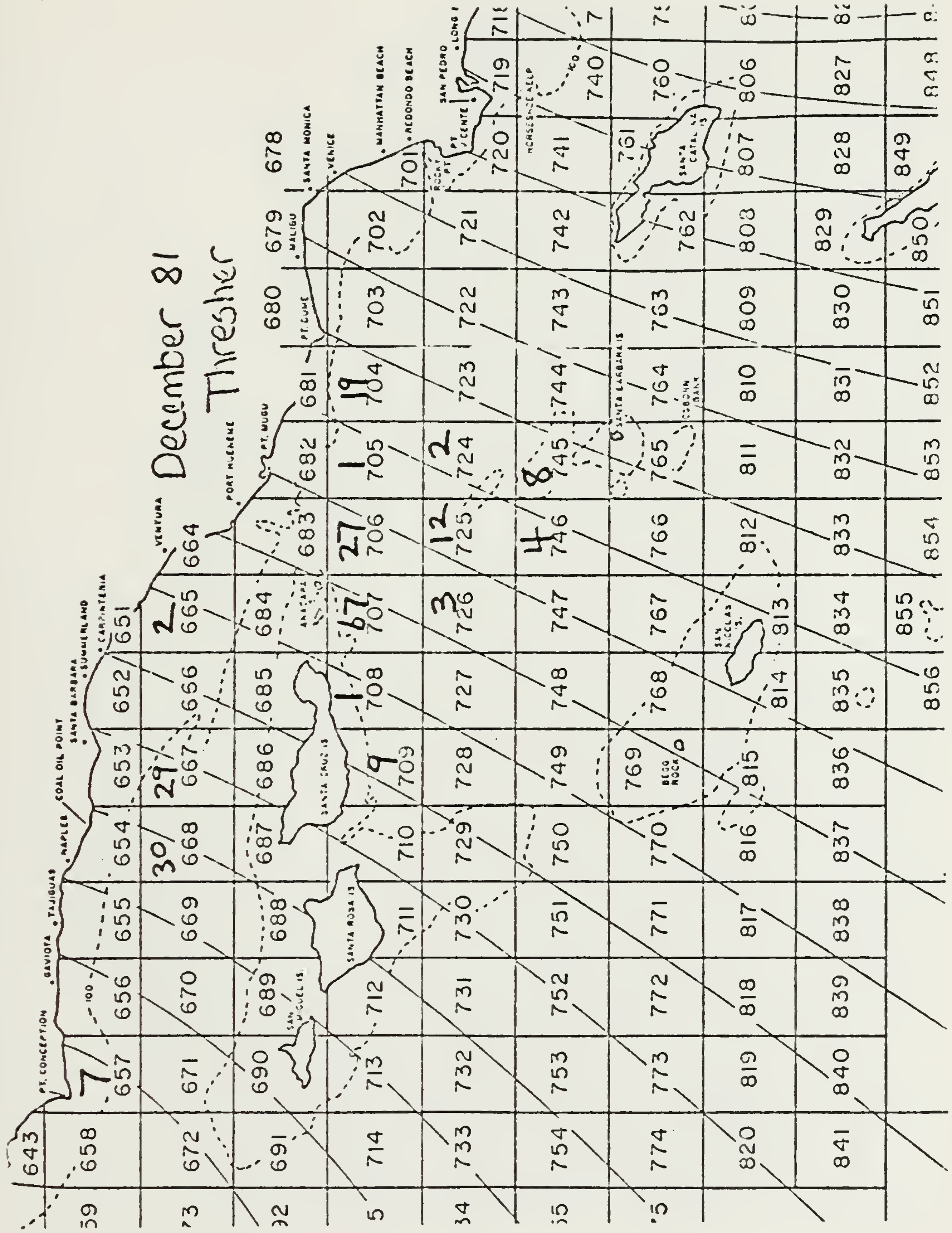
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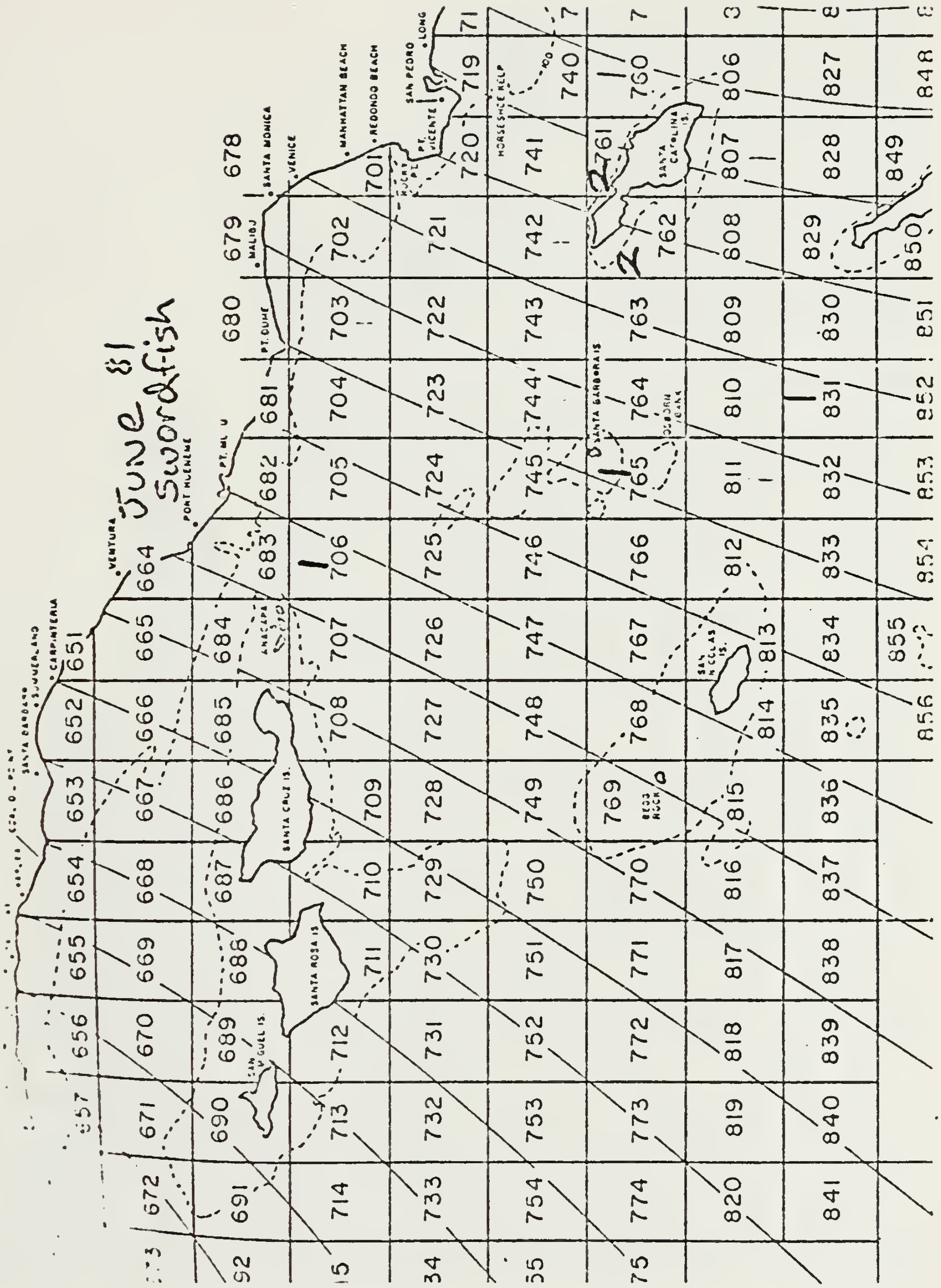
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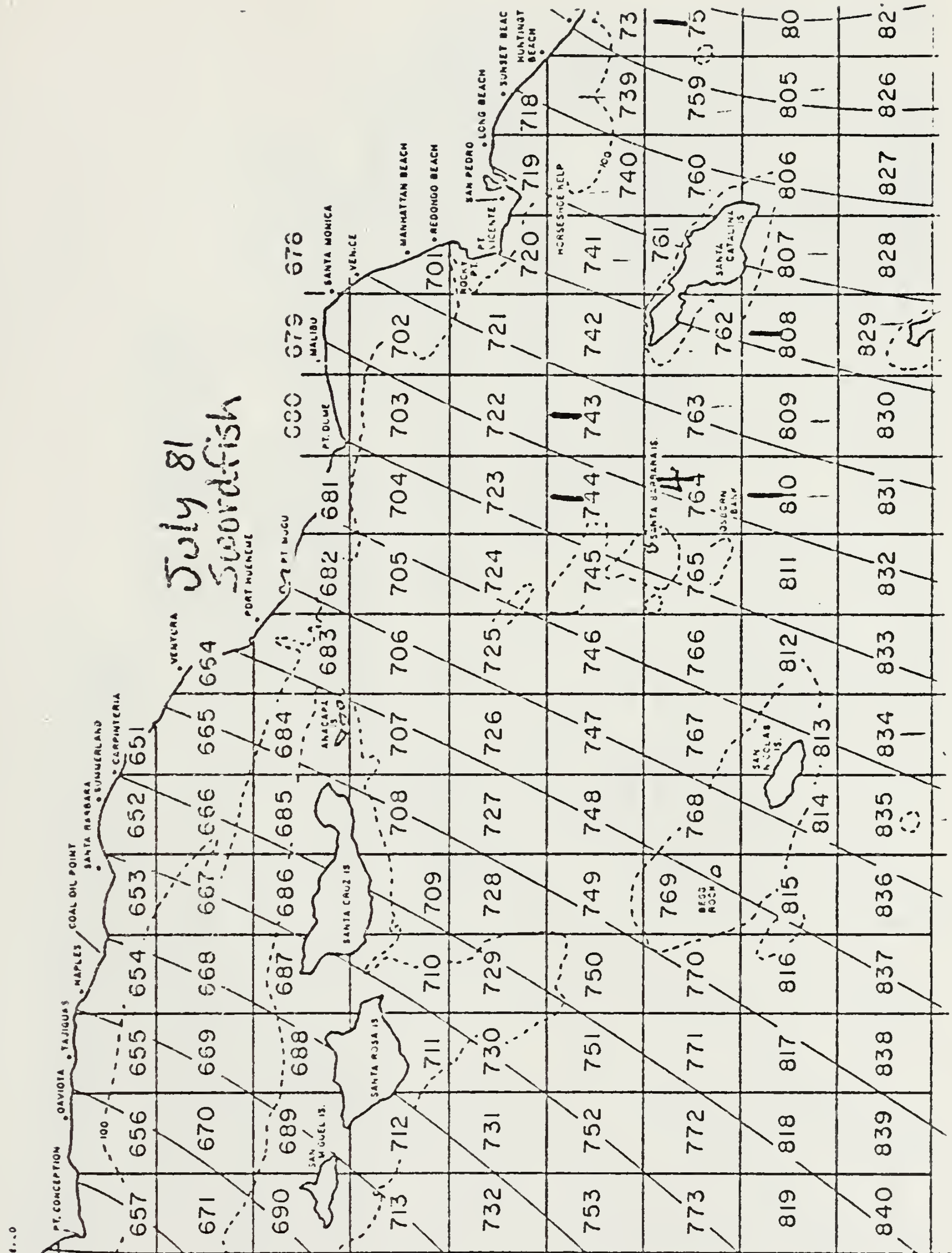
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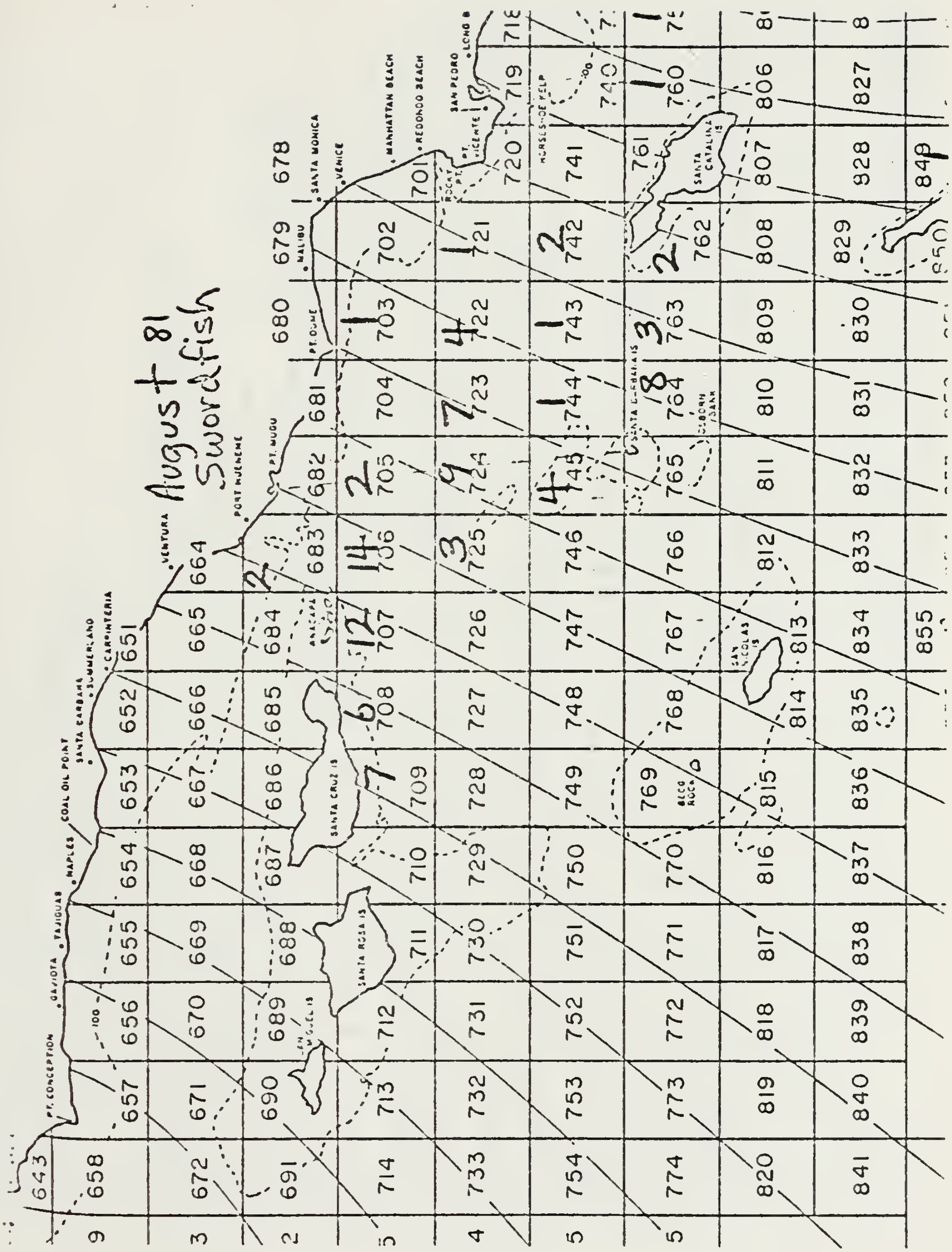
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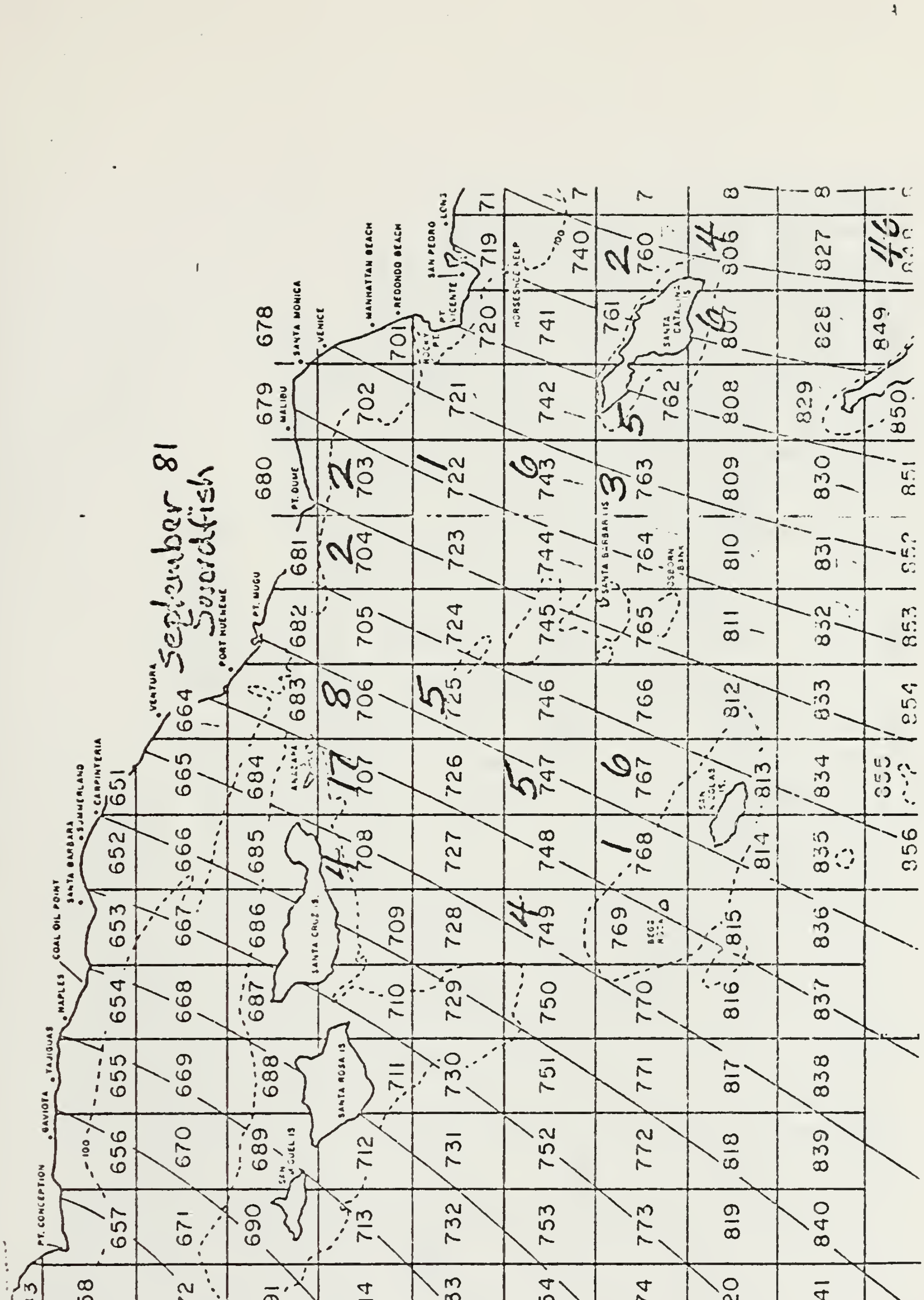
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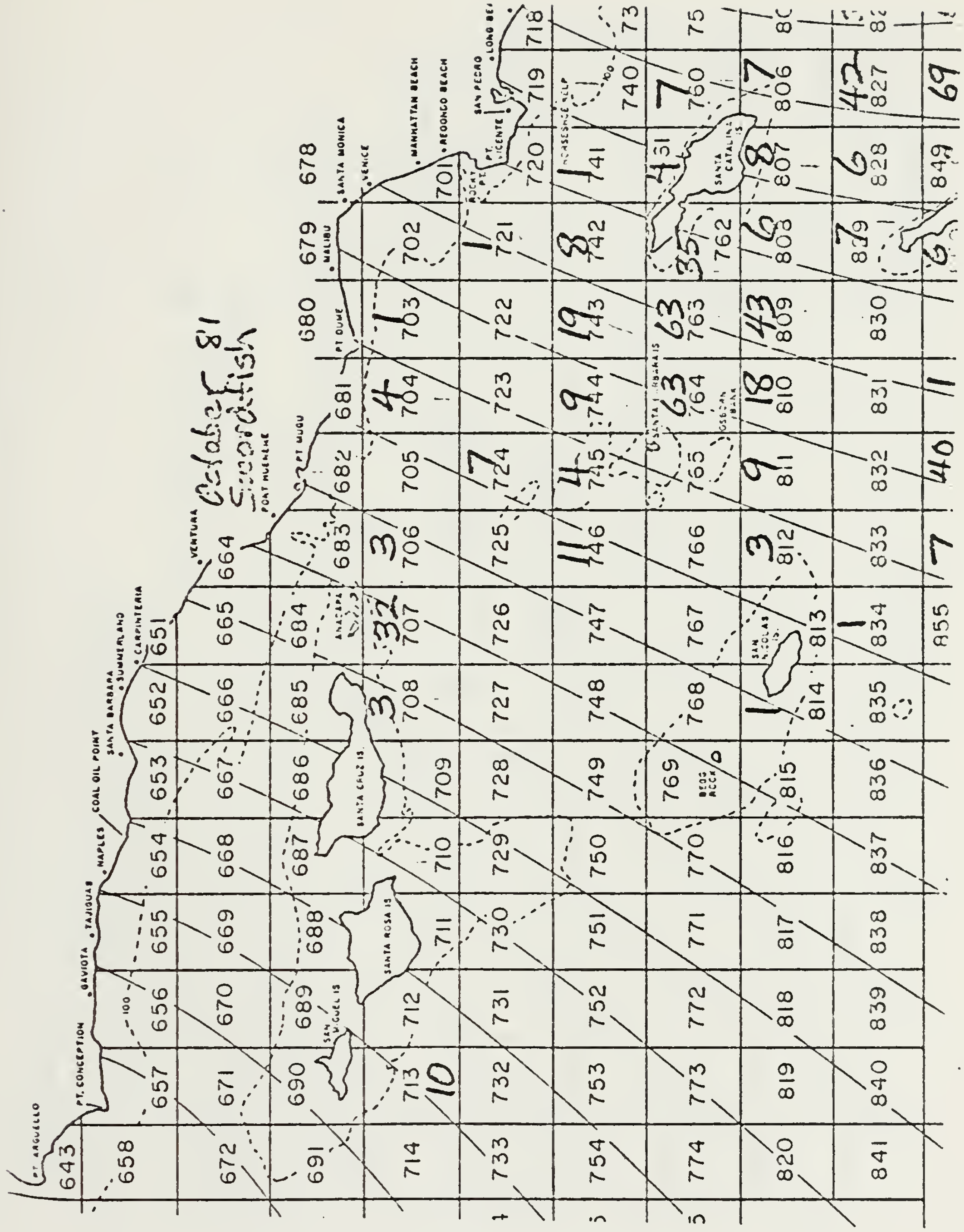
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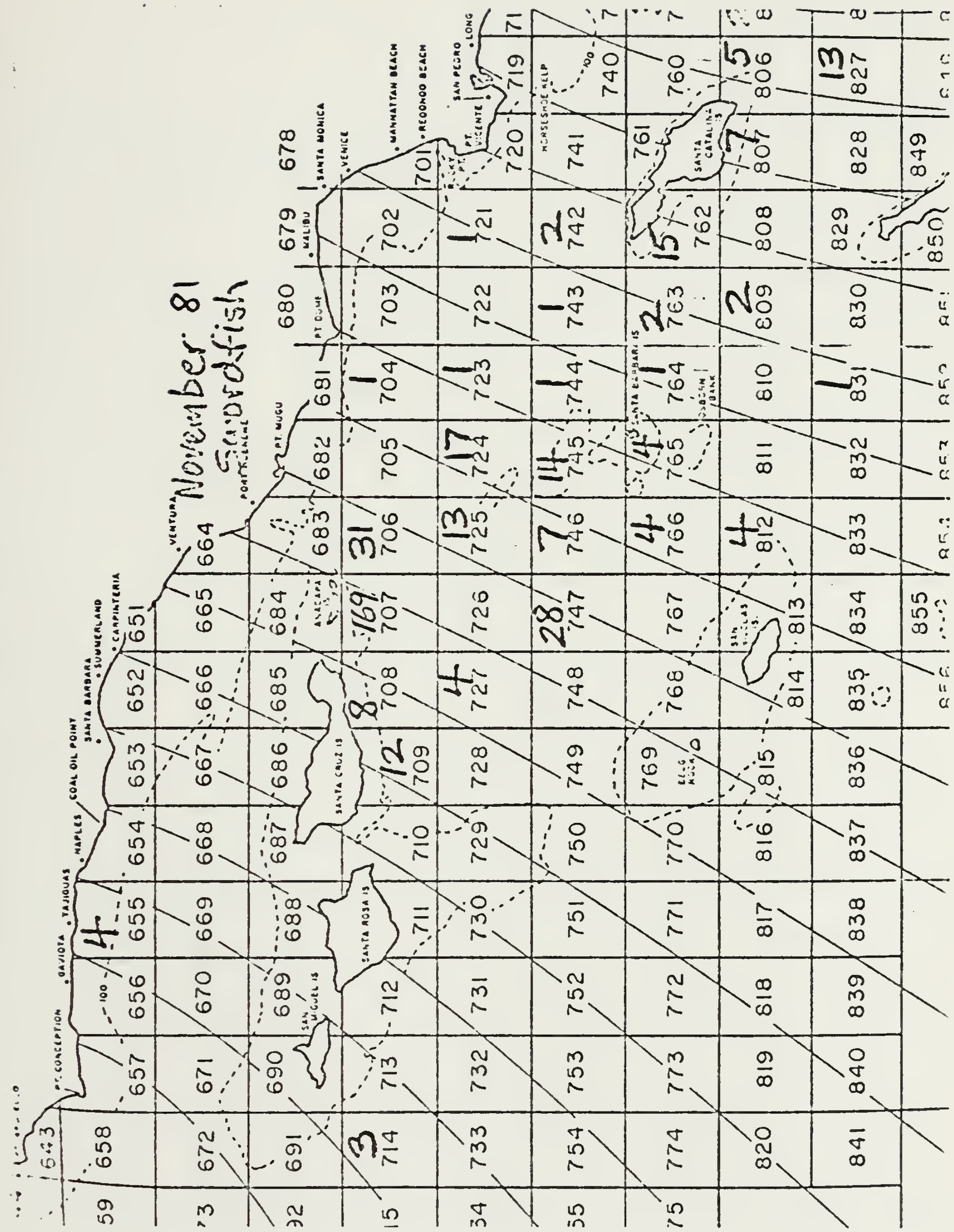
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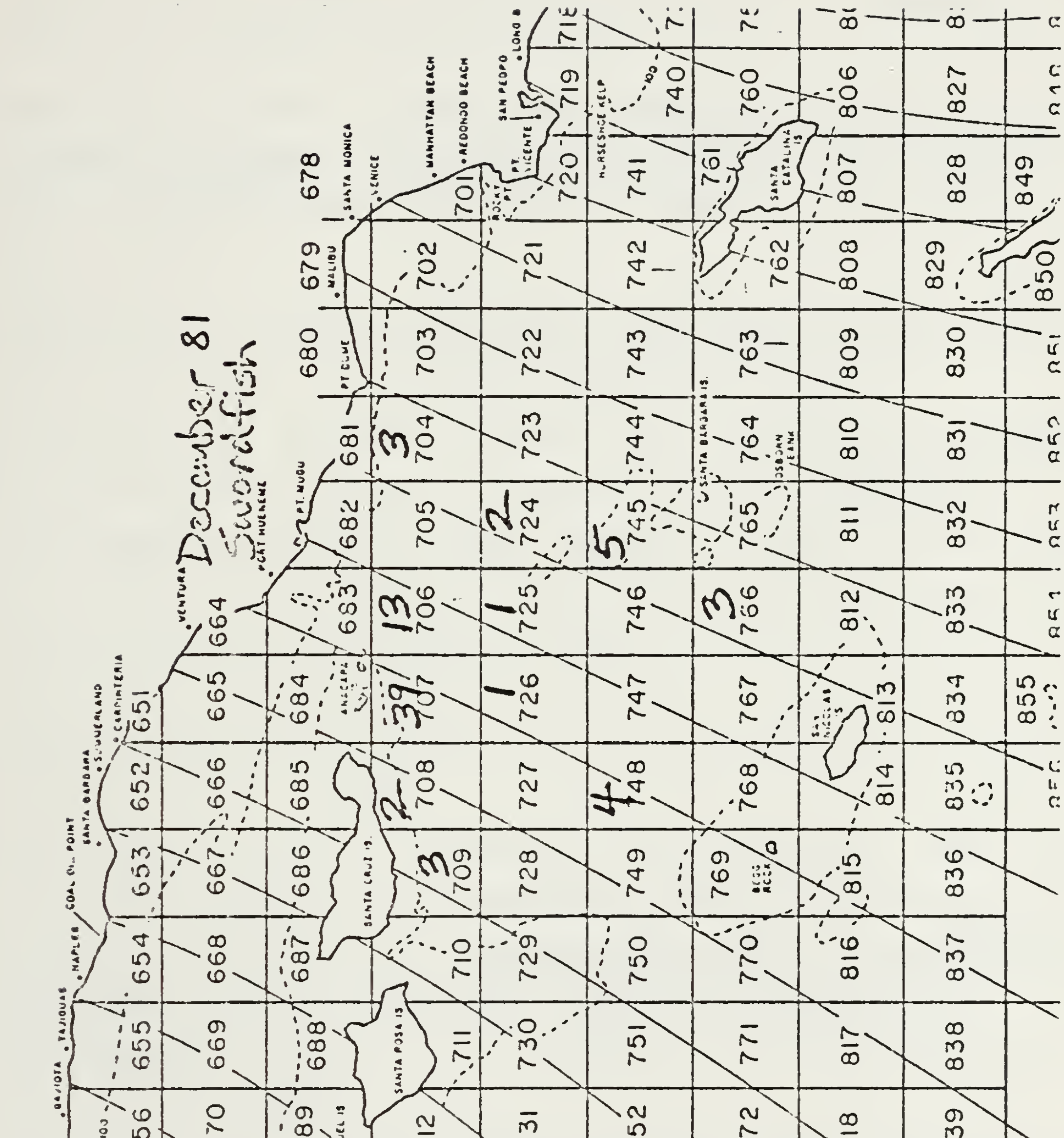

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